MOFFAT
COLLECTION SYSTEM PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

Chapter 2:
Proposed Action and Alternatives

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2.0 INTRODUCTION

The Council on Environmental Quality (CEQ) characterizes the alternatives as the "heart of the environmental impact statement" (40 Code of Federal Regulations [CFR] 1502.14). Defining a reasonable range of alternatives is key to all subsequent analyses and alternatives are measured against the Purpose and Need Statement as discussed in Chapter 1. The Moffat Collection System Project (Moffat Project or Project) Purpose and Need Statement is as follows:

> *The purpose of the Moffat Collection System Project is to develop 18,000 acre-feet per year of new, firm yield to the Moffat Treatment Plant and raw water customers upstream of the Moffat Treatment Plant pursuant to the Board of Water Commissioners' commitment to its customers.*

Both CEQ's regulations for implementing National Environmental Policy Act of 1969, as amended (NEPA) and the United States (U.S.) Army Corps of Engineers' (Corps) NEPA Implementation Procedures (33 CFR 325, Appendix B) require consideration of a reasonable range of alternatives. However, there are differences in approach to defining the alternatives.

NEPA requirements for reasonable alternatives: The CEQ NEPA regulations require that an Environmental Impact Statement (EIS) "rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR 1502.14[a]). In determining the range of reasonable alternatives to be considered, the CEQ states: "the emphasis is on what is reasonable rather than on whether the proponent or applicant likes or is itself capable of carrying out a particular alternative. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint using common sense, rather than simply desirable from the standpoint of the applicant" ("Forty Most Asked Questions Concerning NEPA," Question 2a). Under NEPA, the comparison of a full spectrum of alternatives should provide "a clear basis for choice among options for the decision maker and the public" (40 CFR 1502.14).

Corps requirements for practicable alternatives: For Corps permit actions, the alternatives analysis should comply with the Corps' Section 404(b)(1) Guidelines (40 CFR 230). The Guidelines specifically require that "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant environmental consequences" (40 CFR 230.10[a]). In accordance with these Guidelines, the focus is on the least environmentally damaging practicable alternative (LEDPA). An alternative is considered practicable if it is "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes" (40 CFR 230 Subpart B). The least environmentally damaging alternative is defined as the alternative with the least amount of impacts to the aquatic ecosystem.

It should be noted that, since the Guidelines define the aquatic ecosystem as waters of the U.S., jurisdictional issues apply in the application of the Guidelines. However, due to the large number of initial alternatives and subsequent considerable effort required to determine jurisdiction, all waters were evaluated irrespective of jurisdiction during the early screenings.

The alternatives must satisfy the Guidelines as well as the public interest review (33 CFR 320.4[a]). Therefore, for Corps permit actions, the range of practicable alternatives is typically a subset of reasonable alternatives under NEPA. According to the Corps' NEPA guidance, the alternatives analysis for actions subject to NEPA and the Guidelines can be integrated simultaneously to ensure alternatives carried forward for analysis are practicable and that the LEDPA has not been eliminated from further consideration. The comparison of alternatives should "allow a complete and objective evaluation of the public interest and a fully informed decision regarding the permit application" (33 CFR 325 Appendix B 9 [b][5]).

2.1 PRELIMINARY ALTERNATIVES SCREENING PROCESS

The alternative screening process is described in detail in the Moffat Collection System Project EIS Alternatives Screening Report (Corps 2007a). As described in this section, the alternatives screening process for the Moffat Project was conducted in accordance with both NEPA and the Section 404(b)(1) Guidelines. The identification, verification, evaluation, and screening of all known alternatives were conducted by the Corps, with review and input from the U.S. Environmental Protection Agency (EPA) and the Federal Energy Regulatory Commission (FERC) as Cooperating Agencies and from Grand County as a Consulting Agency.

The overall screening approach was performed in two phases—Screen 1 and Screen 2.

- **Screen 1** progressed from a wide spectrum of potential water supplies and infrastructure components to a well-defined set of Project alternatives using numerous evaluation criteria related to Purpose and Need, existing technology, logistics, costs, and environmental consequences.
  - **Screen 1a** – A broad range of 303 potential water supply sources and infrastructure components were identified, which could be part of a Project alternative to supply water to the Moffat Water Treatment Plant (WTP). A set of exclusionary criteria were used to eliminate those sources or components not capable of meeting the basic Project Purpose and Need, or that have fatal flaws. A total of 261 sources or components were screened out, leaving 42 to be carried forward to Screen 1b, including 29 storage components.
  - **Screen 1b** – The remaining 42 water supply sources and infrastructure components were used to formulate possible Project alternatives by matching a potential water source with water storage and conveyance components that would meet the Project Purpose and Need. A preliminary environmental screen was conducted on the remaining 29 potential storage sites to help configure the potentially least environmentally damaging alternatives. A total of 21 storage sites were eliminated, leaving eight sites, plus deep aquifer storage and gravel pit storage. The storage components and water sources were combined to formulate 34 Project alternatives carried forward to Screen 1c.
  - **Screen 1c** – The 34 Project alternatives were next screened on the basis of relative major capital costs. The rough order-of-magnitude (ROM) estimates were converted to a relative cost index based on the least cost alternative. Those alternatives not considered practicable from a cost perspective were eliminated. The remaining 14 alternatives were carried forward for further evaluation in Screen 2.
- **Screen 2** involved a more in-depth analysis of the Project alternatives using criteria focused on environmental impacts to the aquatic environment and other natural ecosystems. The results of Screen 2 are a set of five alternatives to be carried forward for further analysis in the EIS. These five alternatives represent a reasonable range of practicable alternatives that encompass a variety of potential water supplies and storage sites.

The following section provides more detail on each of these screening steps. Refer to the complete alternative screening report (Corps 2007a) for more information on the screening process that was conducted for this EIS.

2.1.1 Screen 1a

Screen 1a progressed from a wide spectrum of potential water supplies and infrastructure components to a set of Project alternatives using evaluation criteria related to Purpose and Need, existing technology, logistics, and environmental consequences. Each category contained several pass-fail criteria to screen water supply sources and infrastructure components. Failure to satisfy any one criterion was justification for elimination. Table 2-1 presents the list of criteria used in Screen 1a.

Table 2-1
Screen 1a Criteria

Screening Category	Criterion Description		Rationale/Basis for Screening Criterion
Purpose and Need			
	PN1	Must provide new firm yield	To advance, a contribution toward meeting the Project Purpose and Need of 18,000 AF/yr of additional firm yield must be achieved.
	PN2	Must supply water to Moffat Collection System	To advance, the supply must be delivered to the Moffat Collection System to satisfy the Project Purpose and Need for additional supply to support the Moffat Water Treatment Plant and raw-water customers upstream of the Moffat Water Treatment Plant pursuant to the Board of Water Commissioners' (Denver Waters') commitment to its customers.
	PN3	Must produce a solution within the necessary near-term timeframe	To advance, a water source, component (water storage and conveyance infrastructure), or alternative must produce additional firm yield within the near-term timeframe.
Existing Technology			
	ET1	Must use proven technology and management practices	To advance, technological methods or management practices must be tested and proven to minimize risks of failure to provide firm yield.
	ET2	Must not require extreme or extraordinary technical effort to overcome conditions at a site	To advance, known site conditions must not compromise the technical feasibility or long-term reliability of a component or alternative. Physical conditions resulting in high risk or unusual engineering solutions that may not adequately accommodate long-term performance should not be present. These include potential landslides, fault lines, hazardous drainage from mines or mine tailing, or abandoned mine tunnels.

Table 2-1 (continued)
Screen 1a Criteria

Screening Category	Criterion Description		Rationale/Basis for Screening Criterion
Logistics			
Geographic Location	**LG1**	Must be within the State of Colorado and in the South Platte and mainstem Colorado river basins	To advance, water sources, components, or alternatives must be in Colorado and in the South Platte or mainstem Colorado river basins. Exploring options located outside of Colorado would add significant logistical and schedule challenges by requiring interstate cooperation, coordination, and operation. Exploring options outside the South Platte and mainstem Colorado river basins would necessitate acquiring water rights from new filings, purchasing and transferring existing water rights, and developing extensive new infrastructure to import the water. Obtaining water from the Gunnison, Yampa, White, North Platte, Rio Grande, San Juan/Dolores, or Arkansas river basins would be extremely difficult, if not impossible, in a timeframe consistent with the Purpose and Need.
	LG2	Must be outside national and State parks, designated wild and scenic or wilderness areas, and Superfund sites	To advance, water sources, components, or alternatives must not lie within areas that clearly create a significant disadvantage in the evaluation process. In the case of national and State parks and designated wild and scenic or wilderness areas, these reserves were established to create or preserve, in varying degrees, areas of common usage, aesthetics, environmental values and ecosystems. Development of water supply features in these areas would either be explicitly forbidden by statute or regulation or very difficult to accomplish. The implications of providing water for municipal use involving a contaminated site is not considered a reasonable or practicable option.
	LG3	Must be outside lands or sites known to be integral to development plans of other entities	To advance, water sources, components, or alternatives must not lie within areas known to be integral to the development plans of other entities. The conflicts and costs associated with pre-empting or displacing an already planned development should be avoided. The further along in the planning and development process, by others, that a particular area or site is, the greater the associated cost and conflict. Sites or areas that are currently and publicly part of an active permitting process or in any way part of a known, active development plan by an entity with credible standing and capability to advance the plan were eliminated. This criterion does not necessarily preclude alternatives that could be developed jointly under a cooperative effort.

Table 2-1 (continued)
Screen 1a Criteria

Screening Category	Criterion Description		Rationale/Basis for Screening Criterion
Logistics			
Institutional Issues	**LI1**	Must not require Congressional action	To advance, water sources, components, or alternatives must not involve Federal facilities or property that would require Congressional action to authorize its use. Obtaining Congressional approvals could add significant time to the process and jeopardize completion in a timeframe consistent with the Purpose and Need statement.
	LI2	Must conform to Federal, State, and local laws, rules and ordinances	To advance, a component or alternative must not have any known or blatantly unacceptable legal or institutional issues. Examples of options that would involve such issues would include actions contrary to Colorado water rights or water quality laws and regulations, the clear violation of any State or Federal statutes, and the violation of an interstate compact.
	LI3	Must not require relocation of an interstate highway	To advance, a component or alternative must not involve relocation of interstate highways, which are critical infrastructure and would involve significant effort and cost to relocate. Numerous options would meet the Project Purpose and Need that do not involve relocation of interstate highways.
Practicality Issues	**LP1**	Must be capable of storing at least 15,000 AF in a surface impoundment	To advance, alternatives must consist of a manageable level of additional storage and conveyance components. Providing a firm yield of 18,000 AF/yr will likely require approximately 72,000 AF of new surface water storage based on a storage-to-firm yield ratio of 4:1. A minimum storage volume for any one component is needed to reduce the number of possible storage elements to a manageable and practical combination. A minimum storage of 15,000 AF per site could require as many as five new surface storage sites. Incorporating that many surface storage sites into an alternative is probably too complex to reasonably implement and manage. However, with this minimum storage volume, sufficient flexibility remains to consider components that might possibly be combined into a reasonable alternative in a subsequent phase of screening.
	LP2	Water must be available (physically and legally) from a sustainable source in amounts sufficient to be practically developed	To advance, a water supply must be physically available and legally obtainable from a sustainable source in sufficient amounts and with sufficient frequency to satisfy the need for additional firm yield in a practical manner. Firm yields are considered insufficient to be practically developed if they supply less than approximately 20% of the additional firm yield required. Yields are considered insufficient to practically provide additional firm yield if there is less than 15,000 AF available with a frequency of less than 1 year out of 4. These limits are intended to provide flexibility in formulating alternatives, yet prevent the incorporation of extraordinary levels of complexity in the implementation and operation of an alternative.

Table 2-1 (continued)
Screen 1a Criteria

Screening Category		Criterion Description	Rationale/Basis for Screening Criterion
Environmental Consequences			
	EC1	Must not involve new impoundments on major waterways	To advance, a new impoundment must not be located on a major waterway. Construction of a new storage impoundment on a major waterway would be at a considerable disadvantage compared to off-channel and enlargement options due to environmental impacts and the likelihood of opposition. Major waterways are considered to be the main stems of the South Platte and North Fork South Platte rivers; Tarryall Creek; North and West Clear creeks and Clear Creek; North, South, and Middle Boulder creeks and Boulder Creek; St. Vrain Creek and North, Middle, and South Forks of St. Vrain Creek; Big Thompson River; Little Thompson River; Colorado River; Eagle River; Blue River; Williams Fork River and Fraser River. However, new storage components located off-channel, on an intermittent stream, or on an intermittent tributary will be considered, as well as the enlargement or rehabilitation of an existing facility on a major waterway.
	EC2	Must use highest quality water available among similar components within a water sources category	To advance, a component or alternative must use the highest quality water source available when compared to similar components or alternatives within the same water source group. This is a matter of basic public health, is consistent with industry planning guidelines, and is fundamental to Denver Water's mission of providing high quality water to its customers. This criterion provides a basis for selection among components similar in strategy and function, but cannot be applied to eliminate entire water source groups.
	EC3	Must not have any known environmental or permitting fatal flaws	To advance, a water source, component, or alternative must not have any known unmitigatable or unacceptable environmental or socioeconomic issues. Examples of options that would involve such negative consequences include destruction of fens or clear violation of State or Federal environmental statutes.

Notes:
% = percent
AF = acre-feet
AF/yr = acre-feet per year
EC = Environmental Consequences
ET = Existing Technology
LG = Logistics – Geographic Location
LI = Logistics – Institutional Issues
LP = Logistics – Practicality Issues
PN = Purpose and Need

2.1.1.1 Long List of Water Supply Sources and Components

A wide array of water sources and infrastructure components (e.g., storage sites, conveyance routes, water management practices, etc.) was developed based on past studies, extensive literature review, comments received during the NEPA scoping period, and input from the Board of Water Commissioners (Denver Water), the Corps, and third-party consulting team. Table 2-2 summarizes the types of sources and components evaluated. Table B-1 in Appendix B provides the complete list of these sources and components. Exclusionary criteria described in Table 2-1 were used to eliminate those water supplies or infrastructure components not capable of meeting the Project Purpose and Need, or that have fatal flaws, leaving 42 water supply sources and infrastructure components that were carried through to Screen 1b.

Table 2-2
Description of Water Supply Sources and Infrastructure Components in the "Long List"

Category	General Description of the Entries
West Slope Reservoirs	Expansion of existing reservoir sites and new dam sites.
New Reservoirs - Front Range	Potential storage sites in the South Platte, Cache la Poudre, St. Vrain, Big Thompson, Clear Creek, and Boulder Creek drainage basins.
Existing Reservoirs - Front Range	Existing storage sites within the same drainage basins as new reservoir sites.
Institutional/non-structural Water Management Concepts	Non-structural concepts such as cooperative agreements and reallocation/exchange of water supplies.
Reuse and Treatment Concepts	Options involving reuse of Denver Water's reusable effluent.
Demand Reduction	Options that reduce demands on Moffat Collection System supplies. Conservation or demand reduction is intrinsic to Denver Water's Purpose and Need, and would be included in all alternatives carried forward to the EIS. Refer to Denver Water's Integrated Resource Plan for details on conservation measures (Denver Water 2002a).
Agricultural Conversion and Other Water Purchases	Water purchase arrangements (three in the South Platte River Basin and two in the Blue River Basin).
Surface Water (South Platte and Colorado river basins) Supplies	Water rights acquisition in the Colorado and South Platte river basins.
Groundwater	Aquifer Storage and Recovery options, which involve placing surplus water underground in either bedrock aquifers or shallow alluvial aquifers, for recovery at a later time when supplies are needed.
Conveyance Facilities	Conveyance structures such as pipelines, tunnels, and diversions to convey water from its source to the Moffat Water Treatment Plant.
Diverse and Distant Sources of Supply	Other sources of water supply – Colorado River Return Project and other out-of-basin purchases.

Table 2-3 summarizes the number of water sources and components eliminated by each criterion. As shown in Table 2-3, the most significant criteria used to eliminate water supply sources and infrastructure components were:

- **PN2** – Must supply water to the Moffat Collection System
- **LP1** – Must be capable of storing at least 15,000 acre-feet (AF) in a surface impoundment

- **LP2** – Water must be available (physically and legally) from a sustainable source in amounts sufficient to be practicably developed
- **EC1** – Must not involve new impoundments on major waterways

Table 2-3
Screen 1a Summary

Designation	Description	Number of Components/ Water Sources Eliminated
Purpose and Need		
PN1	Must provide new firm yield.	3
PN2	Must supply water to Moffat Collection System.	19
PN3	Must produce a solution within the necessary near-term timeframe.	15
Existing Technology		
ET1	Must use proven technology and management practices.	1
ET2	Must not require extreme or extraordinary technical effort to overcome conditions at a site.	7
Logistics – Geographic		
LG1	Must be within the State of Colorado and in the South Platte and mainstem Colorado river basins.	4
LG2	Must be outside national and State parks, designated wild and scenic or wilderness areas, and Superfund sites.	9
LG3	Must be outside lands or sites known to be integral to development plans of other entities.	15
Logistics – Institutional		
LI1	Must not require Congressional action.	12
LI2	Must conform to Federal, State, and local laws, rules and ordinances.	0
LI3	Must not require relocation of an interstate highway.	2
Logistics – Practicality		
LP1	Must be capable of storing at least 15,000 AF in a surface impoundment.	94
LP2	Water must be available (physically and legally) from a sustainable source in amounts sufficient to be practicably developed.	37
Environmental Consequences		
EC1	Must not involve new impoundments on major waterways.	58
EC2	Must use highest quality water available among similar components within a water sources category.	0
EC3	Must not have any known environmental or permitting fatal flaws.	1

Notes:
AF = acre-feet
EC = Environmental Consequences
ET = Existing Technology
LG = Logistics – Geographic Location
LI = Logistics – Institutional Issues
LP = Logistics – Practicality Issues
PN = Purpose and Need

Table B-2 in Appendix B lists the water supply sources and components that were remaining at the conclusion of Screen 1a. These elements were used to formulate Project alternatives in Screen 1b.

2.1.2 Screen 1b

The objective of Screen 1b was to match a potential water supply source with water storage and conveyance components to formulate possible Project alternatives that would meet the Project Purpose and Need. Screen 1b was conducted in 4 steps: (1) assessment of available water supplies, (2) assessment of available storage and conveyance components, (3) preliminary environmental screen of storage sites, and (4) configuration of possible alternatives.

Potential water supply sources remaining after Screen 1a were assessed based on the acceptable quality and delivery point. The water supply sources that were identified that could reasonably be expected to meet the supply needs of the Moffat Project included:

- Denver Water's existing water rights in the following basins:
  - South Platte River
  - Williams Fork River
  - Fraser River
  - Blue River
  - South Boulder Creek
- Unappropriated water from the upper South Platte and Blue river basins
- Reusable water from the South Platte River (trans-basin and/or fully consumable South Platte water not used to extinction)
- Acquisition of existing agricultural water rights from other entities (purchasing senior agricultural water rights and dry year leasing arrangements)

A total of 29 storage components passed through Screen 1a and were considered available for storage development or enlargement as part of a potential Project alternative. Similar storage components were grouped by geographic proximity to allow for a relative comparative analysis of sites.

A preliminary environmental screen was conducted on the potential storage sites remaining after Screen 1a to help configure the potentially least environmentally damaging alternatives. The objective of the preliminary environmental screen was to screen storage components with the greatest adverse impact to the aquatic environment and other natural habitats without limiting the range of alternatives to be further evaluated. Based on a relative comparison of storage components within each geographic grouping, the storage component with the least adverse impacts to the environment was selected for Project alternative formulation. A total of 24 surface reservoir sites, and five shallow aquifer storage sites were evaluated in the environmental screen. The results of the preliminary environmental screen were eight remaining reservoir sites, plus deep aquifer storage and gravel pit storage.

These remaining storage sites were combined with the remaining water supply sources and infrastructure components from Screen 1a to formulate possible Project alternatives that meet the Project Purpose and Need. Thirty-four (34) alternatives were formulated by matching a potential water source with water storage and conveyance components (Table 2-4). Conceptual figures of each alternative are provided in Appendix B (Figures B-1 through B-32).

Table 2-4
Project Alternatives Evaluated in Screen 1b

	Alternative Name	Description
1	**Moffat Collection System/Existing Infrastructure Project** Predominately wet-year Fraser River, Williams Fork River, and South Boulder Creek would be the water source using the existing Moffat Collection System infrastructure.	
a	South Boulder Creek Storage	Storage to firm up the yield is provided by an **enlarged Gross Reservoir (72,000 AF additional)**.
b	Ralston North Storage	Storage to firm up the yield is provided by a **new Leyden Gulch Reservoir (72,000 AF)**.
c	Large South Boulder Creek and Small Ralston North Storage	Storage to firm up the yield is provided by an **enlarged Gross Reservoir (52,000 AF additional)** and a **new Leyden Gulch Reservoir (20,000 AF)**.
c.1	Large Storage North of South Boulder Creek and Small Ralston North Storage	Storage to firm up the yield is provided by a **new Sixmile Canyon Reservoir (35,000 AF)** and a **new Leyden Gulch Reservoir (37,000 AF)**. A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
d	Small South Boulder Creek and Large Ralston North Storage	Storage to firm up the yield is provided by an **enlarged Gross Reservoir (20,000 AF additional)** and a **new Leyden Gulch Reservoir (52,000 AF)**.
d.1	Small Storage North of South Boulder Creek and Large Ralston North Storage	Storage to firm up the yield is provided by a **new Sixmile Canyon Reservoir (20,000 AF)** and a **new Leyden Gulch Reservoir (52,000 AF).** A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
2	**Moffat Collection System/Williams Fork Extension Project** The same water as described for Alternative 1, plus predominately wet-year water that can be obtained by constructing gravity-flow extensions to the existing Williams Fork Collection System. Water conveyed via the Gumlick Tunnel is released into Clear Creek (instead of continuing on to the Moffat Tunnel). Water conveyed in Clear Creek Basin is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	Clear Creek-South Boulder Creek Storage	Storage to firm up the yield is obtained by adding storage in a **new Soda Creek Reservoir (32,000 AF)** and in an **enlarged Gross Reservoir (40,000 AF additional)**.
a.1	Clear Creek Storage – Storage North of South Boulder Creek	Storage to firm up the yield is obtained by adding storage in a **new Soda Creek Reservoir (37,000 AF)**, a **new Sixmile Canyon Reservoir (35,000 AF),** and **expanding Gross Reservoir by 5,000 AF**. A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
b	Clear Creek-Ralston North Storage	Storage to firm up the yield is obtained by adding storage in a **new Soda Creek Reservoir (32,000 AF)** and in a **new Leyden Gulch Reservoir (40,000 AF)**.
c	Ralston South Storage	Storage to firm up the yield is obtained by adding new storage in an **enlarged Ralston Reservoir (72,000 AF additional)**. Water conveyed via Clear Creek is collected at a new diversion near Golden and conveyed via a shortened version of Conduit X to the enlarged Ralston Reservoir.

Table 2-4 (continued)
Project Alternatives Evaluated in Screen 1b

Alternative Name		Description
3	**Moffat Collection System/Williams Fork - South Fork Extension Project** The same water as described for Alternative 2, plus predominately wet-year water that can be obtained by constructing a new storage reservoir on the South Fork Williams Fork River and pumping back up to a gravity-flow extension of the existing Williams Fork Collection System. Water conveyed via the Gumlick Tunnel is released into Clear Creek (instead of continuing on to the Moffat Tunnel). Water conveyed in Clear Creek Basin is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	Clear Creek-South Boulder Creek Storage	Storage to firm up the yield is obtained by adding storage in a **new reservoir on the South Fork Williams Fork River (12,000 AF),** a **new Soda Creek Reservoir (32,000 AF)**, and in an **enlarged Gross Reservoir (28,000 AF additional)**.
a.1	Clear Creek Storage-Storage North of South Boulder Creek	Storage to firm up the yield is obtained by adding storage in a **new reservoir on the South Fork Williams Fork River (12,000 AF), a new Soda Creek Reservoir (32,000 AF)**, and in a **new Sixmile Canyon Reservoir (28,000 AF)**. A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
b	Clear Creek-Ralston North Storage	Storage to firm up the yield is obtained by adding storage in a **new reservoir on the South Fork Williams Fork River (12,000 AF),** a **new Soda Creek Reservoir (32,000 AF)**, and in a **new Leyden Gulch Reservoir (28,000 AF)**.
4	**Blue River/South System Interconnect Project** Predominately wet-year Blue River water is conveyed via the Roberts Tunnel to a new tunnel constructed from the Roberts Tunnel to the Bear Creek drainage. Water conveyed in Bear Creek would be collected at a diversion in the vicinity of Morrison/Bear Creek Reservoir and conveyed via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	Bear Creek Delivery/Ralston South Storage	Storage to firm up the yield is obtained by adding storage in an **enlarged Ralston Reservoir (72,000 AF additional).**
5	**Blue River/North System Delivery Project** Predominately wet-year Blue River water (the same water in Alternative 4) is conveyed via a new tunnel from Dillon Reservoir to the Clear Creek drainage (downstream of Georgetown). Water stored in Clear Creek Basin is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	Clear Creek Storage	Storage to firm up the yield is obtained by adding storage in a **new Soda Creek Reservoir (72,000 AF)**.
b	Ralston South Storage	Storage to firm up the yield is obtained by adding new storage in an **enlarged Ralston Reservoir (72,000 AF additional)**.
6	**Indirect Potable Reuse Project** Denver Water Recycling Plant effluent is treated in an AWTP.	
a	Ralston South Storage	Storage to firm up the yield is obtained by adding storage in an enlarged **Ralston Reservoir (72,000 AF additional)**. At the reservoir, the advanced wastewater treatment reuse water would be blended with fresh water, retained for 12 months, and then delivered to the Moffat Collection System delivery point near SH 72.
b	Ralston North Storage	Storage to firm up the yield is obtained by adding storage in a **new Leyden Gulch Reservoir (72,000 AF)**. At the reservoir, the advanced wastewater treatment reuse water would be blended with fresh water, retained for 12 months, and then delivered to the Moffat Collection System delivery point near SH 72.
7	**Reusable Water** Reusable water in the South Platte River is collected at a gravel pit forebay and treated in a new AWTP.	
a	Ralston South Storage	Storage to firm up the yield is obtained in an **enlarged Ralston Reservoir (72,000 AF additional)**.
b	Ralston North Storage	Storage to firm up the yield is obtained in a **new Leyden Gulch Reservoir (72,000 AF)**.

Table 2-4 (continued)
Project Alternatives Evaluated in Screen 1b

Alternative Name		Description
8	**Shallow Aquifer Storage Project** Using the same water as described for Alternative 1, plus reusable water in the South Platte River as described in Alternative 7. Reusable water is collected at a gravel pit forebay and pumped to the Box Elder Creek Basin via a bi-directional pipeline. Surface-spreading basins are used to charge the aquifer, and water is collected with recovery wells and returned to the Moffat Collection System delivery point via Conduits M and Z near SH 72. The shallow aquifer storage required for Alternatives 8a and 8b is primarily a function of the amount of reusable effluent available. As configured, these alternatives assume that 5,000 AF of new firm yield would be generated through the storage and recovery of reusable effluent. Therefore, at a storage-to-firm yield ratio of 4:1, 20,000 AF of storage capacity would be needed. Further alternative development and refinement in subsequent phases will be required to determine the amount of firm yield that could potentially be generated with reusable effluent and the amount of shallow aquifer storage required.	
a	South Boulder Creek Storage	Storage to firm up the yield is obtained in a new **Box Elder Creek shallow aquifer recharge/recovery facility (20,000 AF)** and an **enlarged Gross Reservoir (52,000 AF additional)**.
b	Ralston North Storage	Storage to firm up the yield is obtained in a new **Box Elder Creek shallow aquifer recharge/recovery facility (20,000 AF)** and a **new Leyden Gulch Reservoir (52,000 AF)**.
9	**Agricultural Water Conversion Project** Agricultural water rights, located downstream of the Metro Wastewater Reclamation District Plant (Metro WWTP), are purchased and converted to municipal/industrial use. A new diversion on the South Platte River in the vicinity of Greeley collects water and conveys it to a proposed storage facility. Treatment process upgrades are made at Moffat WTP.	
a	Metro Northeast Storage	Storage to firm up the yield is obtained in an **enlarged Spring Creek Reservoir (up to 36,000 AF)** from where water is delivered to the Moffat Collection System delivery point near SH 72.
b	Ralston North Storage	Storage to firm up the yield is obtained in a **new Leyden Gulch Reservoir (up to 72,000 AF)**.
10	**Deep Aquifer Storage Project** Using the same water as described for Alternative 1, plus Denver Water Recycling Plant effluent that is treated in an AWTP. Treated water is pumped to dedicated injection wells to recharge the Denver Basin aquifer located within the City and County of Denver. Recovered water is collected from the wells, chlorinated at the wellhead, manifolded into new conveyance pipes, and pumped to existing treated water storage in the Moffat Service Area. The deep aquifer storage required for Alternatives 10a and 10b is primarily a function of the amount of reusable effluent available. As configured, these alternatives assume that 5,000 AF of new firm yield would be generated through the storage and recovery of reusable effluent. Therefore, at a storage-to-firm yield ratio of 4:1, 20,000 AF of storage capacity would be needed. Further alternative development and refinement in subsequent phases will be required to determine the amount of firm yield that could potentially be generated with reusable effluent and the amount of deep aquifer storage required.	
a	Deep Aquifer and South Boulder Creek Storage	Storage to firm up the yield is obtained in the **Denver Basin aquifer (20,000 AF)** and in an **enlarged Gross Reservoir (52,000 AF additional)**.
b	Deep Aquifer and Ralston North Storage	Storage to firm up the yield is obtained in the **Denver Basin aquifer (20,000 AF)** and in a **new Leyden Gulch Reservoir (52,000 AF)**.
c	Deep Aquifer and Ralston South Storage	Storage to firm up the yield is obtained in the **Denver Basin aquifer (20,000 AF)** and an **enlarged Ralston Reservoir (52,000 AF additional)**. Predominately wet-year Blue River water (same as in Alternative 4) is conveyed via the Roberts Tunnel to a new tunnel constructed from the Roberts Tunnel to the Bear Creek drainage. Water conveyed in Bear Creek would be collected at a diversion in the vicinity of Morrison/Bear Creek Reservoir and conveyed via a shortened version of Conduit X to storage in an enlarged Ralston Reservoir.

Table 2-4 (continued)
Project Alternatives Evaluated in Screen 1b

Alternative Name		Description
d	Deep Aquifer and Clear Creek Storage	Storage to firm up the yield is obtained in the **Denver Basin aquifer (20,000 AF)** and a **new Soda Creek Reservoir (52,000 AF)**. Predominately wet-year Blue River water (the same as in Alternative 5) is conveyed via a new tunnel from Dillon Reservoir to the Clear Creek drainage (downstream of Georgetown). Storage to firm up the yield is obtained by adding storage in a new Soda Creek Reservoir. Water conveyed via Clear Creek is then collected at a diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.
e	Ralston South Storage	Storage to firm up the yield is obtained in the **Denver Basin aquifer (20,000 AF)** and an **enlarged Ralston Reservoir (52,000 AF additional)**. Predominately wet-year Blue River water (the same as in Alternative 5) is conveyed via a new tunnel from Dillon Reservoir to the Clear Creek drainage (downstream of Georgetown). Storage to firm up the yield is obtained by adding storage in an enlarged Ralston Reservoir. Water conveyed via Clear Creek is then collected at a diversion downstream of Golden and conveyed via a shortened version of Conduit X to the enlarged Ralston Reservoir.
11	**Deep Aquifer plus Shallow Aquifer Storage Project** Denver Water's reusable water in the South Platte River would be collected at a gravel pit forebay. New storage would be provided in both shallow and deep aquifers. The shallow and deep aquifer storage required for Alternative 11 is primarily a function of the amount of Denver Water's reusable effluent available. As configured, this alternative assumes that 18,000 AF of new firm yield would be generated through the storage and recovery of reusable effluent. Therefore, at a storage-to-firm yield ratio of 4:1, 72,000 AF of storage capacity would be needed. Further alternative development and refinement in subsequent phases will be required to determine the amount of firm yield that could potentially be generated with reusable effluent and the amount of shallow and deep aquifer storage required.	
a	Deep Aquifer Storage and Shallow Aquifer Storage	Advanced water treatment of the reusable water would be provided before pumping to dedicated injection wells to recharge the **Denver Basin aquifer (20,000 AF)** located within the City and County of Denver. Recovered water is collected from the wells, chlorinated at the wellhead, manifolded into new conveyance pipes, and pumped to existing treated water storage in the Moffat Service Area. Other reusable water is pumped to the **Box Elder Creek Basin (52,000 AF)** via a bi-directional pipeline. Surface-spreading basins are used to charge the aquifer, and water is collected with recovery wells and returned to the Moffat Collection System delivery point near SH 72.
12	**Deep Aquifer Storage, South System Project** Wet-year South Collection System water, diverted from the South Platte River or Blue River, is conveyed to the Marston and Foothills WTPs using existing infrastructure. Wet-year water is conveyed when available to the WTPs, where it is treated using existing unused capacity. Excess water is considered to be regularly available 1 year out of 3 years over a 4-month runoff period of April through July. Water availability and availability of unused treatment capacity were assumed to coincide.	
a	South System Aquifer Storage and Recovery	Storage to firm up the yield is provided by pumping to injection and recovery wells within the **Denver Basin aquifer (54,000 AF)** distributed throughout the City and County of Denver. This approach makes use of Denver Water's existing treated water distribution system to convey the water to the injection/recovery wells. Recovered water is collected from the wells, chlorinated at the wellhead, manifolded into new conveyance pipes, and pumped to existing treated water storage in the Moffat Service Area.
13	**Agricultural Water Rights Purchase, Moffat Collection System Project** Using the same water as described for Alternative 1, plus **a**gricultural water rights. These new rights, located downstream of the Metro WWTP, are purchased, and converted to municipal/industrial use to generate 3,000 AF/yr of new firm yield. A new diversion on the South Platte River in the vicinity between Brighton and Fort Lupton collects water in a gravel pit forebay. An AWTP would be located near the forebay to provide treatment prior to gravel pit storage or delivery to the Moffat Collection System. Water is delivered from the gravel pit via Conduits Z and M to the Moffat Collection System delivery point near SH 72.	
a	Agricultural Water Rights Purchase and South Boulder Creek Storage	Storage to firm up the yield is obtained in a **new gravel pit forebay (3,625 AF)** and an **enlarged Gross Reservoir (60,000 AF additional)**.

Table 2-4 (continued)
Project Alternatives Evaluated in Screen 1b

Alternative Name		Description
b	Agricultural Water Rights Purchase and Ralston North Storage	Storage to firm up the yield is obtained in a **gravel pit forebay (3,625 AF of storage) and** in a **new Leyden Gulch Reservoir (60,000 AF)**.
14	**Reusable Water, Agricultural Water Rights Purchase, and Moffat Collection System Project** Using the same water as described for Alternative 1, plus reusable water in the South Platte River as described in Alternative 8, and agricultural water rights as described in Alternative 13.	
	Gravel Pit Storage and South Boulder Creek Storage	Reusable return flows in the South Platte River, generating 5,000 AF/yr firm yield, would be diverted to new gravel pit storage facilities near Brighton, Colorado, similar to Alternative 8a. Agricultural water rights would be purchased and converted to municipal/industrial use to generate 3,000 AF/yr firm yield, similar to Alternative 13a. A total of approximately **8,625 AF gravel pit storage** would be needed. An AWTP would be located near the gravel pits to provide treatment prior to delivery to the Moffat Collection System. Water would be delivered via Conduit O to the Moffat Collection System delivery point near SH 72. Using existing collection infrastructure, water from the Fraser River, Williams Fork River, and South Boulder Creek is diverted and delivered during average to wet years via the Moffat Tunnel and South Boulder Creek, and stored in an **enlarged Gross Reservoir (40,000 AF additional)**.

Notes:
AF = acre-feet
AF/yr = acre-feet per year
AWTP = Advanced Water Treatment Plant
SH = State Highway
WTP = Water Treatment Plant

2.1.3 Screen 1c

The 34 Project alternatives developed in Screen 1b were screened on the basis of relative major capital costs in Screen 1c. ROM and relative development cost (RDC) estimates were developed and used to eliminate alternatives with excessive costs. The surviving alternatives were carried forward for further evaluation in Screen 2.

ROM Project costs were developed based on the estimated quantity/capacity of the principal elements of each potential alternative (e.g., length of tunnel, pipeline length/diameter, volume of dam, pump station capacity, and water treatment facility capacity) as follows:

- Estimates for surface storage components were determined by embankment volumes and construction type (earthen, concrete, or roller-compacted concrete).
- Conveyance elements were estimated with cost curves for pipelines, pump stations, and tunnels.
- Advanced water treatment facilities and well fields were estimated based on unit costs, including cost per gallon of treatment capacity, and cost per well, respectively.

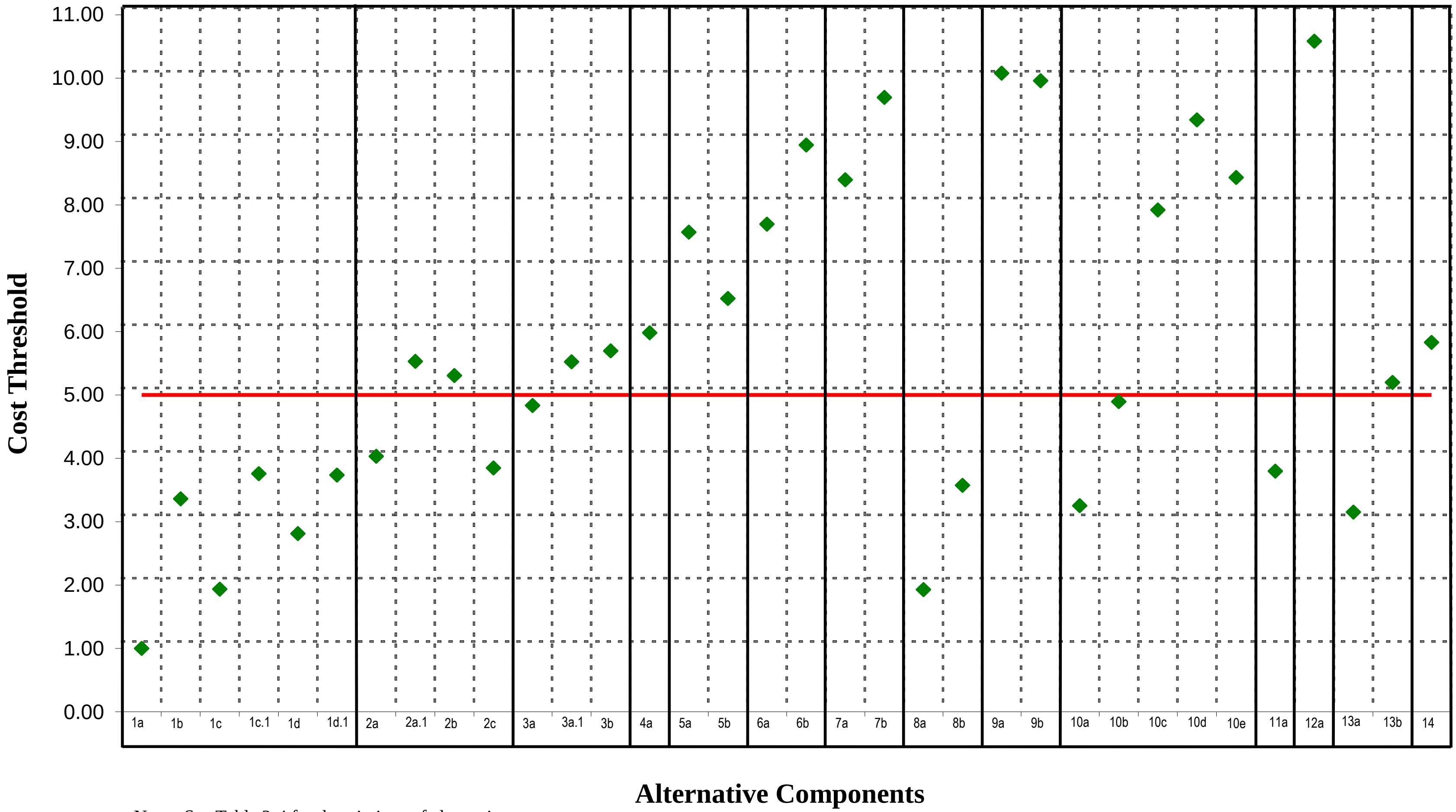
While the ROM cost reflects the total capital cost of major infrastructure features of an alternative, it does not represent the expected total Project cost. To develop a more representative cost estimate that is suitable for use in comparing alternatives, an RDC was developed for Screen 1c. The ROM cost for each alternative was converted to an RDC or total potential Project development cost, by applying a 50 percent (%) factor to account for unknowns, contingencies, and total development cost escalation. Operation and maintenance (O&M) costs were not included at this level of cost estimating.

The resulting RDC estimates were converted to a dimensionless, relative-cost screen by expressing each estimate in terms of the estimated least cost alternative (a ratio). The alternatives were then ranked according to their associated relative cost index for screening. The Corps decided upon a cost threshold of 5.0 to be conservative and more inclusive in the cost screen, while ensuring that a reasonable range of alternatives are maintained in the EIS that would meet the Project Purpose and Need, as well as complying with the requirements of the Section 404(b)(1) Guidelines. The selection of the 5.0 ratio for the cost index also considered information available from other major Colorado water supply projects at the time the screening was completed for this Project. Table 2-5 shows the results of the cost screen. Alternatives with relative cost indices greater than 5.0 were eliminated from further evaluation. Alternatives 6 and 7 were screened out in the cost screen because they included only reuse to meet the entire 18,000 acre-feet per year (AF/yr) of the firm yield requirement and had high relative cost indices due to the cost of treating such a large volume at an Advanced Water Treatment Plant (AWTP), whereas Alternatives 8a and 10a included indirect potable reuse to meet 5,000 AF/yr of the firm yield requirement. The treatment costs were considerably lower for these alternatives because only a portion of the firm yield requirement would be met with indirect potable reuse. Therefore, they passed the cost screen.

A total of 15 alternatives with relative cost indices less than 5.0 passed Screen 1 for further evaluation in Screen 2. One of the alternatives, however, was eliminated prior to conducting Screen 2 based upon further assessment of the yield criteria of the Project Purpose and Need Statement. Alternative 11a, Deep and Shallow Aquifer Storage of Reusable Supplies, was eliminated because it was determined upon further assessment that this alternative could not supply 18,000 AF/yr of new firm yield. The source of water is unused reusable effluent and lawn irrigation return flows (LIRFs) to recharge both shallow and deep aquifers for subsequent withdrawal.

The results of Screen 1c are a set of 14 alternatives carried forward for further analysis in Screen 2. Table 2-6 lists these alternatives.

Table 2-5
Relative Cost of Project Alternatives



Note: See Table 2-4 for descriptions of alternative components.

Table 2-6
List of Alternatives Evaluated in Screen 2

Alternative Name		Description
1	**Moffat Collection System** Predominantly wet-year Fraser River, Williams Fork River, and South Boulder Creek water would be the water source using existing Moffat Collection System infrastructure.	
a	Gross Reservoir Storage	Storage is provided by an **enlarged Gross Reservoir (72,000 AF additional)**.
b	Leyden Gulch Reservoir Storage	Storage is provided by a **new Leyden Gulch Reservoir (72,000 AF)**.
c	Large Gross Reservoir and Small Leyden Gulch Storage	Storage is provided in an **enlarged Gross Reservoir (52,000 AF additional)** and a **new Leyden Gulch Reservoir (20,000 AF)**.
c.1	Sixmile Canyon Reservoir and Leyden Gulch Reservoir	Storage is provided in a **new Sixmile Canyon Reservoir (35,000 AF)** and a **new Leyden Gulch Reservoir (37,000 AF)**. A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
d	Small Gross Reservoir and Large Leyden Gulch Reservoir	Storage is provided in an **enlarged Gross Reservoir (20,000 AF additional**) and a **new Leyden Gulch Reservoir (52,000 AF)**.
d.1	Small Sixmile Canyon Reservoir and Large Leyden Gulch Reservoir	Storage in a **new Sixmile Canyon Reservoir (20,000 AF)** and a **new Leyden Gulch Reservoir (52,000 AF)**. A new bi-directional transmission line and pumping system supplies water to and from the new Sixmile Canyon Reservoir.
2	**Moffat Collection System/Williams Fork Extension** Using the same water as described for Alternative 1, plus predominately wet-year water that can be obtained by constructing gravity-flow extensions to the existing Williams Fork Collection System. Water conveyed via the Gumlick Tunnel is released into Clear Creek (instead of continuing to the Moffat Tunnel). Water conveyed via Clear Creek is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	Soda Creek Reservoir and Gross Reservoir	Storage is provided in a **new Soda Creek Reservoir (32,000 AF)** and in an **enlarged Gross Reservoir (40,000 AF additional)**. Water conveyed via Clear Creek is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.
c	Ralston Reservoir	Storage is provided in an **enlarged Ralston Reservoir (72,000 AF additional)**. Water conveyed via Clear Creek is collected at a new diversion near Golden and conveyed via a shortened version of Conduit X to the enlarged Ralston Reservoir.
3	**Moffat Collection System/Williams Fork – South Fork Extension Project** Using the same water as described for Alternative 1, plus predominately wet-year water that can be obtained from the upper Williams Fork Collection System (similar to Alternative 2). Water conveyed via the Gumlick Tunnel is released into Clear Creek (instead of continuing to the Moffat Tunnel). Water conveyed via Clear Creek is collected at a new diversion downstream of Golden and delivered via a shortened version of Conduit X to the Moffat Collection System delivery point near SH 72.	
a	South Fork Reservoir, Soda Creek Reservoir, and Gross Reservoir	Storage is provided in a **new reservoir constructed on the South Fork Williams Fork River (12,000 AF)** and pumped back up to a gravity-flow extension of the existing Williams Fork Collection System. Storage is also provided in a **new Soda Creek Reservoir (32,000 AF)** and in an **enlarged Gross Reservoir (28,000 AF additional)**.
8	**Moffat Collection System/Shallow Aquifer Storage** Using the same water as described for Alternative 1, plus reusable water in the South Platte River is collected at a gravel pit forebay and pumped to the Box Elder Creek Basin via a bi-directional pipeline. Surface-spreading basins are used to charge the aquifer, and water is collected with recovery wells and returned to the Moffat Collection System delivery point via Conduits M and Z near SH 72.	
a	Box Elder Creek Shallow Aquifer and Gross Reservoir	Storage is provided in a **new Box Elder Creek shallow aquifer recharge/recovery facility (20,000 AF)** and an **enlarged Gross Reservoir (52,000 AF additional)**.
b	Box Elder Creek Shallow Aquifer and Leyden Gulch Reservoir	Storage is provided in a **new Box Elder Creek shallow aquifer recharge/recovery facility (20,000 AF)** and a **new Leyden Gulch Reservoir (52,000 AF)**.

Table 2-6 (continued)
List of Alternatives Evaluated in Screen 2

Alternative Name		Description
10	**Moffat Collection System/Deep Aquifer Storage Project** Using the same water as described for Alternative 1, plus Denver Water Recycling Plant effluent that is treated in an AWTP. Treated water is pumped to dedicated injection wells to recharge the Denver Basin aquifer located within the City and County of Denver. Recovered water is collected from the wells, chlorinated at the wellhead, and conveyed via new conduits to the Moffat Collection System delivery point.	
a	Deep Aquifer and Gross Reservoir	Storage is provided in the **Denver Basin aquifer (20,000 AF)** and an **enlarged Gross Reservoir (52,000 AF additional)**.
b	Deep Aquifer and Leyden Gulch Reservoir	Storage is provided in the **Denver Basin aquifer (20,000 AF)** and a **new Leyden Gulch Reservoir (52,000 AF)**.
13	**Moffat Collection System/Agricultural Water Conversion** Using the same water as described for Alternative 1, plus agricultural water rights. These rights, located downstream of the Metro WWTP are purchased, and converted to municipal/industrial use to generate 3,000 AF/yr of new firm yield. A new diversion on the South Platte River in the vicinity between Brighton and Fort Lupton collects water in a gravel pit forebay. An AWTP would be located near the forebay to provide treatment prior to gravel pit storage or delivery to the Moffat Collection System. Water is delivered from the gravel pit via Conduits Z and M to the Moffat Collection System delivery point near SH 72.	
a	Agricultural Water Rights Purchase, Gravel Pit Storage, and Gross Reservoir	Storage is provided in a **gravel pit forebay (3,625 AF)** and an **enlarged Gross Reservoir (60,000 AF additional)**.

Notes:
AF = acre-feet
AF/yr = acre-feet per year
AWTP = Advanced Water Treatment Plant
SH = State Highway
WWTP = Wastewater Treatment Plant

2.1.4 Screen 2

Screen 2 focused on environmental consequences to the aquatic environment, other ecosystems, and other natural environmental values since these areas would be permanently affected by implementation of the alternatives, such as reservoir inundation, and construction of dams, roads, and diversion structures. In addition, the technological feasibility of deep aquifer storage and advanced water treatment of reuse water was considered.

The five categories of evaluation criteria used in Screen 2 include:

- Wetlands
- Aquatic Habitat (inundation)
- Aquatic Habitat (depletions)
- Threatened and Endangered Species
- Other Habitat Values (designated wildlife habitat areas, significant habitat features, and Colorado Natural Heritage Program potential conservation areas)

The evaluation criteria were applied to each alternative using a combination of reconnaissance-level field observations, and review of existing data, maps, and aerial photography. Site visits were conducted to check existing data and collect additional information on existing conditions. The reservoir sites visited include existing sites

(Gross and Ralston reservoirs) and potential reservoir sites (Leyden Gulch, Sixmile Canyon, and Soda Creek). Refer to the conceptual figures of Project alternatives in Appendix B of the Moffat Collection System Project EIS Alternatives Screening Report for a location of the existing and potential reservoir sites (Corps 2007a). For each category of evaluation criteria, an overall score and a relative ranking were developed in order to compare alternatives. Weighted scores were developed by multiplying the assigned resource value for each resource feature (e.g., an individual wetland or stream segment that would be affected) by a measurement of the amount of effect. Effect was evaluated by change in distance, area, or volume, depending on the resource, and was measured with a Geographic Information System device. This was repeated for all affected resources and a total score was derived for each category of evaluation criteria.

Relative rank orders for each alternative were developed within each evaluation category, with 1 having the least environmental effect and 5 representing the greatest environmental effect. A rank order is calculated within each category of criteria by determining the range between the lowest and the highest scoring alternative and dividing that amount by five (the desired number of rank orders in this case). The quotient of that division is then added to the lowest scoring alternative and that number represents the range of scores falling within the first rank order. This is repeated for each subsequent rank order. For example, if the scores among alternatives for wetlands ranged from 10 to 95, the range (85) divided by 5 would be 17. The first rank order would include those alternatives scoring from 10 to 27; the second rank order would include scores of 28 to 45; etc. The results of applying Screen 2 evaluation criteria are shown in Table 2-7, which displays the weighted scores and rank orders for all alternatives. Each evaluation category was treated as having equal weight (i.e., wetlands are not considered as being more or less important than aquatic habitat).

Nine alternatives were eliminated from further consideration due to environmental conflicts and lower comparative rankings (i.e., one or more rank orders of 4 and/or 5). The alternatives eliminated include Alternatives 1b, 1c.1, 1d, 1d.1, 2a, 2c, 3a, 8b, and 10b.

Five alternatives have low to moderate impacts in all categories (i.e., they have a rank order of 1, 2, or 3). Based on these ratings, the following five alternatives are carried forward for further analysis in the EIS.

Proposed Action (Alternative 1a): 72,000 AF enlargement of Gross Reservoir

Alternative 1c: 52,000 AF enlargement of Gross Reservoir combined with a 20,000 AF reservoir at Leyden Gulch

Alternative 8a: 52,000 AF enlargement of Gross Reservoir combined with 20,000 AF of shallow aquifer storage at the Box Elder Creek site

Alternative 10a: 52,000 AF enlargement of Gross Reservoir combined with 20,000 AF of deep aquifer storage

Alternative 13a: 60,000 AF enlargement of Gross Reservoir combined with purchase of agricultural water rights

The five alternatives to be carried forward for EIS analysis represent a reasonable cross-section of practical alternatives, which encompass a broad range of potential water supplies and storage sites. These alternatives all utilize Denver Water's supplies from the Fraser River, Williams Fork River, and South Boulder Creek to varying degrees.

Alternatives 8a, 10a, and 13a utilize Denver Water's reusable water or transferred agricultural water rights to reduce the portion of supply derived from additional trans-mountain diversions. The five alternatives include various combinations and sizes of a Gross Reservoir enlargement and a new Leyden Gulch Reservoir. In addition, Alternatives 8a and 10a rely, to some degree, on shallow and deep aquifer storage instead of surface storage.

Table 2-7
Screen 2 Comparative Ranking Summary

Alternative	Wetlands	Aquatic Habitat (inundation)	Aquatic Habitat (depletions)	Threatened and Endangered Species	Other Habitat Values
1a	1 2.59	2 5.47	3 3.00	1 1.00	2 1562.84
1b	4 24.88	1 1.33	3 3.00	1 3.00	1 31.05
1c	3 16.35	1 4.33	3 3.00	2 4.00	2 1159.03
1c.1	5 26.77	1 3.51	3 3.00	3 6.00	1 928.78
1d	5 25.50	1 3.08	3 3.00	2 4.00	1 360.39
1d.1	5 30.28	1 3.21	3 3.00	3 6.00	1 598.48
2a	3 16.37	4 13.26	3 3.00	4 9.00	4 3037.71
2c	5 30.99	2 7.29	3 3.00	4 9.00	4 3052.23
3a	3 15.68	5 18.78	3 3.00	5 13.00	5 4537.30
8a	1 2.20	1 3.94	3 3.00	1 1.00	2 1131.61
8b	4 24.18	1 1.24	3 3.00	1 3.00	1 30.06
10a	1 2.20	1 3.94	3 3.00	1 1.00	2 1131.61
10b	4 24.18	1 1.24	3 3.00	1 3.00	1 30.06
13a	1 2.16	1 4.17	3 3.00	1 1.00	2 1179.50

Notes:
Numbers in the center of the cells are the rank where 1 = least environmental effect and 5 = the greatest environmental effect. Numbers in the lower right of each cell is the total score.
Ranking denotes the relative ranking of scores within each category. Shading denotes alternatives eliminated from further evaluation based on rank orders of 4 and/or 5.
Other Habitat Values refer to designated wildlife habitat areas, significant habitat features, and Colorado Natural Heritage Program potential conservation areas.

2.1.5 Refinement of EIS Alternatives

After the alternatives screening process was completed, components of the five alternatives were further refined and revised as Denver Water developed additional detail based on further investigations and engineering studies. The major refinements include the following:

- Alternative 1c was re-configured with different reservoir sizes based on feasibility level engineering analysis and an assessment of environmental constraints, primarily wetland habitat. Alternative 1c was finalized with an enlarged Gross Reservoir (additional 40,700 AF) and new Leyden Gulch Reservoir (31,300 AF).
- Alternative 8a was originally configured with a shallow aquifer recharge/recovery facility to firm the reusable supplies. Conceptually, reusable return flows would be used when available to recharge the Box Elder Creek groundwater basin located in Adams County near Brighton. Subsequent analyses conducted by Denver Water, and reviewed by the Corps' third-party consulting team, suggest that the shallow aquifer storage component has serious limitations in comparison to surface storage in gravel pits located along the South Platte River. Thus, Alternative 8a was re-configured with gravel pit storage facilities located along the South Platte River. The gravel pit storage was sized to provide 5,000 AF/yr of firm yield to Denver Water's system.

The Corps analyzed a total of five action alternatives in the EIS, in addition to the No Action Alternative. Table 2-8 presents a summary of the five EIS action alternatives and Section 2.2 more fully explains each alternative.

Table 2-8
List of EIS Alternatives

	Alternative Name	Description
1	**Moffat Collection System** **Predominantly wet-year Fraser River, Williams Fork River, and South Boulder Creek water would be the water source using the existing Moffat Collection System infrastructure.**	
a	Gross Reservoir Expansion	Storage is provided in an **enlarged Gross Reservoir (72,000 AF additional)**.
c	Gross Reservoir Expansion and New Leyden Gulch Reservoir	Storage is provided in an **enlarged Gross Reservoir (40,700 AF additional)** and a **new Leyden Gulch Reservoir (31,300 AF)**.
8	**Gravel Pit Storage/Moffat Collection System**	
a	Gravel Pit Storage and Gross Reservoir Expansion	Unused reusable water in the South Platte River is diverted to a series of new gravel pit storage facilities near Brighton, Colorado. Water is recovered from the gravel pit storage, treated at a new AWTP, and then conveyed to the Moffat Collection System delivery point via Conduit O. Storage is provided in **gravel pits** along the South Platte River **(approximately 5,000 AF)**. Using existing collection infrastructure, water from the Fraser River, Williams Fork River, and South Boulder Creek is diverted and delivered during average to wet years via the Moffat Tunnel and South Boulder Creek, and stored in an **enlarged Gross Reservoir (52,000 AF additional)**.
10	**Deep Aquifer Storage Project/Moffat Collection System**	
a	Deep Aquifer Storage and Gross Reservoir Expansion	Unused reusable water in the South Platte River is diverted to the Denver Water Recycling Plant, treated and transferred to a new AWTP. Advanced water treatment water is pumped to injection wells to recharge the **Denver Basin aquifer (20,000 AF)** located within the City and County of Denver. Recovered water is collected from the wells, manifolded into new conveyance pipes, and pumped to the Moffat Collection System delivery point via Conduit M. Using existing collection infrastructure, water from the Fraser River, Williams Fork River, and South Boulder Creek is diverted and delivered during average to wet years via the Moffat Tunnel and South Boulder Creek, and stored in an **enlarged Gross Reservoir (52,000 AF additional)**.

Table 2-8 (continued)
List of EIS Alternatives

	Alternative Name	Description
13	**Agricultural Water Conversion/Moffat Collection System**	
a	Agricultural Water Rights Purchase, Gravel Pit Storage, and Gross Reservoir Expansion	Agricultural water rights, located downstream of the Metro Wastewater Reclamation District Plant are purchased, and converted to municipal/industrial use to generate 3,000 AF/yr of new firm yield. A new diversion on the South Platte River diverts water to a series of **gravel pit storage facilities (approximately 3,625 AF of storage)** near Brighton, Colorado. Water is recovered from the gravel pit storage, treated at a new AWTP, and then conveyed via Conduit O to the Moffat Collection System delivery point near SH 72. Using existing collection infrastructure, water from the Fraser River, Williams Fork River, and South Boulder Creek is diverted and delivered during average to wet years via the Moffat Tunnel and South Boulder Creek, and stored in an **enlarged Gross Reservoir (60,000 AF additional)**.

Notes:
Individual surface storage reservoir sizes are for purposes of evaluating a practical range of Project alternatives and do not represent the final planned size. Further alternative development and refinement in subsequent Project phases will be required.
AF = acre-feet
AF/yr = acre-feet per year
AWTP = Advanced Water Treatment Plant
SH = State Highway

2.2 OVERVIEW OF ALTERNATIVES

This section describes the following five action alternatives, plus the No Action Alternative, to be evaluated in this EIS:

- Proposed Action (Alternative 1a) – Gross Reservoir Expansion (Additional 72,000 AF)
- Alternative 1c – Gross Reservoir Expansion (Additional 40,700 AF)/New Leyden Gulch Reservoir (31,300 AF)
- Alternative 8a – Gross Reservoir Expansion (Additional 52,000 AF)/Reusable Return Flows/Gravel Pit Storage (5,000 AF)
- Alternative 10a – Gross Reservoir Expansion (Additional 52,000 AF)/Reusable Return Flows/Denver Basin Aquifer Storage (20,000 AF)
- Alternative 13a – Gross Reservoir Expansion (Additional 60,000 AF)/Transfer of Agricultural Water Rights/Gravel Pit Storage (3,625 AF)
- No Action Alternative – The No Action Alternative assumes that Denver Water would not receive approval from the Corps to implement the Moffat Project. The No Action Alternative would require Denver Water to use a combination of strategies to meet the need for additional water supply, including using a portion of its Strategic Water Reserve and imposing mandatory restrictions to help reduce demand during drought periods.

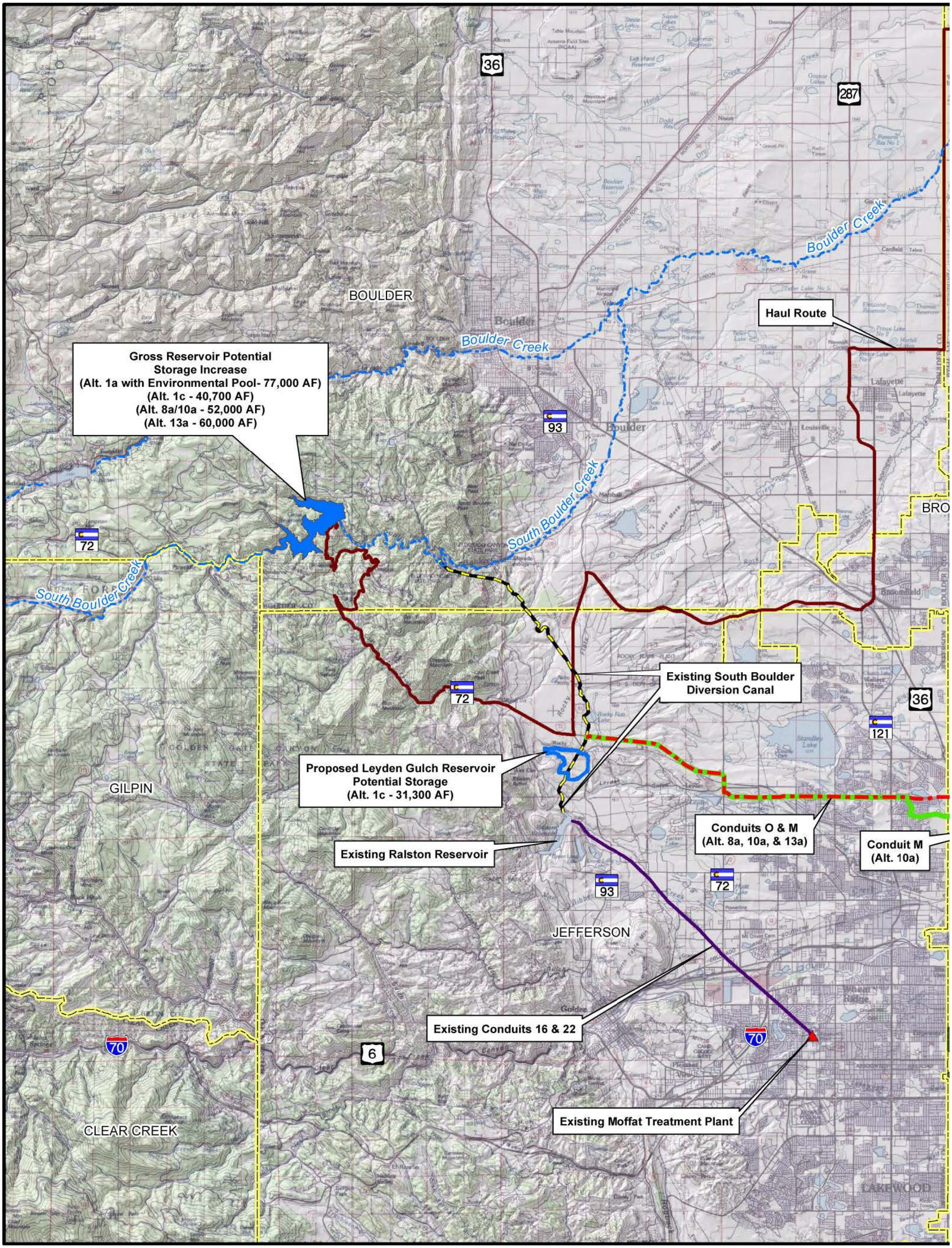
Each action alternative is configured to increase the firm yield of Denver Water's system by 18,000 AF/yr, consistent with the Project Purpose and Need statement (refer to Section 1.2). Table 2-8 provides a summary of the alternatives. Figure 2-1 provides an overview of all Project components and their relative locations.

Potential Water Sources

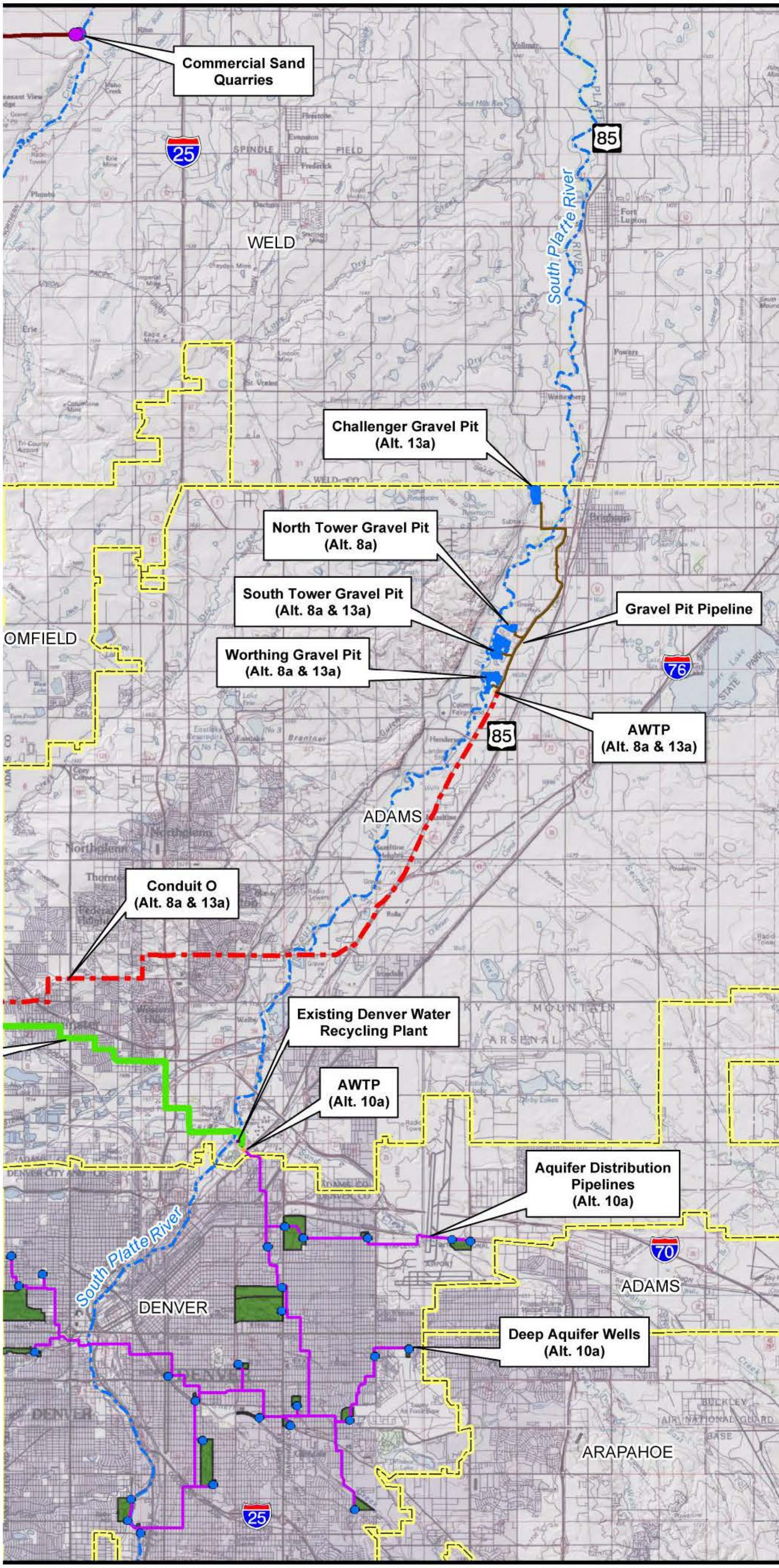
Three potential sources for increased water supply are considered in the five alternative combinations: (1) additional Moffat Collection System supplies (West and East Slope water), (2) reusable return flows on the South Platte River, and (3) South Platte River water rights transfers.

1. Additional Moffat Collection System Supplies

All of the action alternatives would use water supplies derived from the Moffat Collection System (North System). (Refer to Section 1.3.1, and Figure 1-2 for more details on Denver Water's raw water collection system.) Additional water is available for diversion under existing Denver Water water rights from the Fraser River, Williams Fork River, and South Boulder Creek.



BOULDER
Gross Reservoir Potential Storage Increase
(Alt. 1a with Environmental Pool- 77,000 AF)
(Alt. 1c - 40,700 AF)
(Alt. 8a/10a - 52,000 AF)
(Alt. 13a - 60,000 AF)
Boulder Creek
South Boulder Creek
Haul Route
Existing South Boulder Diversion Canal
Proposed Leyden Gulch Reservoir Potential Storage
(Alt. 1c - 31,300 AF)
Existing Ralston Reservoir
Conduits O & M
(Alt. 8a, 10a, & 13a)
Conduit M
(Alt. 10a)
GILPIN
JEFFERSON
BRO
Existing Conduits 16 & 22
Existing Moffat Treatment Plant
CLEAR CREEK
36
287
93
72
121
6
70



Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Moffat Collection System Project FEIS

Figure 2-1 Overview of Alternative Components

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Each of the action alternatives would provide additional storage in the Moffat Collection System. Denver Water would divert additional water from the Fraser River, Williams Fork River, and South Boulder Creek basins in average and wet years. Additional diversions would be greatest in wet years, including wet years following dry year sequences. Without additional storage, Denver Water's diversions are physically constrained in average and wet years from these basins because of limitations of available storage capacity. Denver Water's diversions are legally constrained because of water rights and existing agreements. In dry years, Denver Water's diversions from the Moffat Collection System are not limited to the amount of water available at their diversion points; the physical constraint is not because of available storage capacity on the East Slope. Additional supplies would be used to meet an overall higher level of demand and would be critical during dry periods or to accommodate system disruptions.

Existing diversion and conveyance facilities, including the Moffat Tunnel and South Boulder Diversion Canal, have adequate capacity to divert and convey the additional flow to the potentially enlarged and/or new storage facilities.

2. Reusable Return Flows on the South Platte River

All water delivered by Denver Water to its customers is classified under Colorado Water Law as reusable or non-reusable. Reusable water can be used and reused to extinction, whereas non-reusable water is used and legally accounted for only once. The main sources of reusable water in Denver Water's Collection System are Blue River water delivered through the Roberts Tunnel, Fraser River water diverted by the Meadow Creek system (the only reusable water associated with the Moffat Collection System), and transferred agricultural water rights on the East Slope. The Metro Wastewater Reclamation District Plant (Metro Wastewater Treatment Plant [WWTP]) and the Littleton–Englewood (Bi-City) WWTP are the primary return points of Denver Water's reusable water. Denver Water keeps track of reusable return flows and currently uses, or is planning to use, most of its reusable supplies through river exchanges, transfers to gravel pits, and to supply water for the non-potable recycling project (refer to Section 1.3.1.4). Optimization of reusable water increases Denver Water's system supply and reduces the amount of water diverted from other components of the system.

For purposes of configuring alternatives in the EIS, the amount of unused reusable water was estimated based on Platte and Colorado Simulation Model (PACSM) results for the Full Use of the Existing System scenario, which is described in Section 5.1. Denver Water's average annual demand under the Full Use of the Existing System scenario would be 345,000 AF/yr. As Denver Water's demand increases, their unused reusable supplies increase because additional Blue River water is delivered to meet demand, for example. As shown in Table 2-9, approximately 7,600 AF/yr on average of unused return flows would be available primarily in the winter months, when Denver Water's customer demands, non-potable demands, and exchange potential are relatively low. The amount of unused reusable supplies available would vary considerably from year to year, ranging from 0 AF/yr to as much as 37,555 AF/yr. New storage and conveyance facilities would be needed to make this reusable supply source available when needed by Denver Water. The reusable flows could be combined with other water sources to meet the entire 18,000 AF/yr of new firm yield needed.

Table 2-9
Denver Water's Estimated Unused Reusable Water
(acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1947	0	0	195	701	103	1,331	380	99	347	159	0	0	**3,315**
1948	0	0	0	0	0	143	0	198	218	0	0	0	**559**
1949	172	539	574	1,199	2,998	1,513	4,106	0	0	86	0	0	**11,186**
1950	3	105	558	555	1,475	3,185	2,857	79	0	0	0	86	**8,904**
1951	358	781	5,116	5,224	4,657	3,135	1,948	0	0	0	0	0	**21,219**
1952	121	507	600	5,203	3,368	3,173	1,879	0	42	0	0	0	**14,892**
1953	45	470	503	1,359	2,657	3,522	4,837	0	0	0	0	0	**13,392**
1954	0	41	496	499	1,624	3,189	5,923	59	0	19	49	268	**12,166**
1955	3,785	6,524	6,686	6,877	5,480	4,744	3,346	114	0	0	0	0	**37,555**
1956	0	0	0	0	851	1,098	1,103	0	0	0	0	0	**3,053**
1957	228	523	5,073	7,501	5,911	4,861	1,598	0	144	31	0	0	**25,869**
1958	0	0	0	0	169	0	0	130	72	0	0	173	**544**
1959	2,130	3,591	4,211	3,063	2,200	2,194	296	0	0	0	0	0	**17,685**
1960	29	241	424	480	3,295	1,540	34	6	15	0	0	49	**6,113**
1961	206	224	406	2,951	3,138	2,496	3,149	0	0	0	0	0	**12,571**
1962	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1963	0	289	361	366	2,263	2,685	4,469	172	56	1,851	578	3	**13,093**
1964	2,531	2,905	3,314	3,188	2,747	1,312	2,360	0	0	0	0	0	**18,357**
1965	0	0	200	417	1,621	4,607	1,239	0	0	0	0	0	**8,084**
1966	0	0	0	0	222	239	0	0	0	0	0	0	**461**
1967	0	0	120	378	613	2,977	5,123	48	0	0	0	0	**9,258**
1968	0	0	0	221	149	338	206	0	0	0	0	0	**914**
1969	0	0	0	352	175	417	3,266	31	32	0	0	0	**4,273**
1970	0	0	0	0	247	160	0	0	0	0	0	0	**407**
1971	0	0	0	0	34	35	0	0	0	0	0	0	**69**
1972	0	0	0	0	214	126	0	0	0	0	0	0	**340**
1973	0	0	0	309	336	1,974	591	136	39	0	0	0	**3,384**
1974	31	321	364	382	46	0	47	7	0	0	0	0	**1,197**
1975	0	121	375	660	2,266	1,820	845	0	0	0	0	0	**6,087**
1976	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1977	0	0	0	0	55	227	53	0	0	0	0	0	**335**
1978	137	335	579	4,552	4,246	3,088	4,521	191	0	0	0	59	**17,707**
1979	652	4,489	6,321	7,060	4,605	2,742	179	0	0	0	0	0	**26,047**
1980	0	0	471	353	336	430	169	229	126	0	0	0	**2,114**
1981	0	231	443	1,141	3,616	1,409	1,974	86	0	0	0	0	**8,900**
1982	0	358	454	462	32	373	779	0	0	0	0	0	**2,458**
1983	0	0	0	0	70	0	86	200	113	59	62	89	**678**
1984	202	376	406	403	2,141	1,164	191	140	53	1	0	0	**5,076**
1985	0	0	0	77	241	175	18	94	10	0	0	0	**615**
1986	0	0	0	0	76	154	0	0	0	0	0	0	**230**
1987	0	10	325	328	761	0	36	96	12	0	0	0	**1,568**

Table 2-9 (continued)
Denver Water's Estimated Unused Reusable Water
(acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1988	0	99	335	288	137	306	27	3	1	0	0	0	**1,196**
1989	0	32	342	347	1,974	699	2,938	4	0	0	0	0	**6,336**
1990	0	0	317	393	3,333	4,518	1,082	28	0	0	0	0	**9,671**
1991	0	0	0	307	51	1,021	2,814	9	0	0	0	0	**4,202**
Average	236	514	879	1,280	1,567	1,536	1,433	48	28	49	15	16	**7,602**
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Maximum	3,785	6,524	6,686	7,501	5,911	4,861	5,923	229	347	1,851	578	268	**37,555**

Note:
Estimated unused reusable water based on Platte and Colorado Simulation Model (PACSM) results for Full Use of the Existing System scenario.

Alternative 8a would use unused reusable return flows diverted from the South Platte River as a water source. Alternative 10a would use unused reusable return flows (effluent) from the Denver Water Recycling Plant as a water source. For these alternatives, 13,000 AF/yr of firm yield comes from additional storage in Gross Reservoir, which in turn comes from additional diversions from the Williams Fork and Fraser river basins, and South Boulder Creek. An additional 5,000 AF/yr of firm yield comes from reusable water supplies. The reusable supplies are only used during drought conditions; therefore, these supplies would be used infrequently and only when needed to supplement Moffat Collection System supplies. The reusable supplies would be used to supplement Denver Water's South Platte River, the Blue River, and Moffat Collection System supplies primarily because of the additional costs associated with treatment and conveyance and potential water quality issues associated with blending that water with Moffat Collection System water.

3. South Platte River Water Rights Transfers

Agricultural water rights owned by ditch companies would be purchased, converted to municipal/industrial use and diverted from the South Platte River upstream of Brighton. The firm yield available from this source would depend on the specific rights to be acquired, and new storage and conveyance facilities would be needed to make this reusable supply source available to Denver Water. Alternative 13a would use approximately 3,000 AF/yr of new South Platte River water transfers as a water source combined with additional Moffat Collection System supplies to meet the needed 18,000 AF/yr of new firm yield.

There are many factors, in addition to cost, which affect the amount of water that could be provided by agricultural water rights transfers. The ability to purchase a significant portion of the shares under certain ditches is uncertain because of the competitive market for agricultural water rights and there is no guarantee there will be an adequate number of willing sellers. Three-thousand acre-feet was considered reasonable considering the uncertainties regarding the availability and location of agricultural water rights, the availability of willing sellers, and the competitive market for this water.

Potential Storage Components

Four potential storage components are considered in the five alternatives: (1) Gross Reservoir (existing), (2) Leyden Gulch Reservoir (proposed), (3) gravel pit storage along the South Platte River, and (4) the Denver Basin aquifers.

1. Gross Reservoir

Four expansion scenarios are considered for Denver Water's existing Gross Reservoir: 72,000 AF, 60,000 AF, 52,000 AF, and 40,700 AF of additional storage capacity.

2. Leyden Gulch Reservoir

A new 31,300 AF reservoir would be constructed in Jefferson County.

3. Gravel Pit Storage

A series of gravel pits along the South Platte River would be developed into storage facilities. Two storage scenarios are considered: approximately 5,000 and 3,625 AF. Storage volumes were determined by modeling daily operations of two alternatives that included gravel pits. At these sizes, the gravel pits are adequate to firm the variable water supply and regulate to meet return flow requirements (Alternative 13a). The amount of gravel pit storage is a function of the timing and amount of available water supplies, which include unused reusable supplies and water provided by agricultural water rights transfers.

4. Denver Basin Aquifers

An injection/recovery well field would be developed within the City and County of Denver to provide approximately 20,000 AF of storage in the Denver Basin deep aquifers. Water would be injected into and recovered from the upper Arapahoe, lower Arapahoe, and Laramie-Fox Hills aquifers of the Denver Basin as needed.

Advanced Water Treatment Technologies

The original Moffat WTP, built in 1937 with a capacity of 50 million gallons per day (mgd), has since undergone expansions and improvements to operate at a current capacity of 185 mgd (MWH 2007). Summer production (from May to September) averages approximately 100 mgd or more, and winter production averages approximately 30 mgd. Raw water is delivered to the Moffat WTP from Ralston Reservoir, which is filled with water from the Moffat Collection System via the South Boulder Diversion Canal. The raw water is considered high quality and the Moffat WTP was designed to treat this level of water quality.

The proposed water sources for Alternatives 8a, 10a, and 13a are unused reusable water or agricultural water from the South Platte River, in addition to Moffat Collection System water. Water quality of the South Platte River below Denver is considerably lower than the Moffat Collection System raw water. Potential South Platte River water quality problems include elevated levels of total dissolved solids (TDS), hardness, bacteria, nutrients, emerging contaminants of concern, which can include personal care and pharmaceutical products and endocrine disrupting compounds. The Moffat WTP is not capable of removing high or problematic concentrations of these constituents found in the source water associated with Alternatives 8a, 10a, and 13a. The Moffat WTP would have potential problems complying with regulatory drinking water requirements for the finished water quality under these alternatives. Consequently, an AWTP would be needed as a component of these alternatives.

Two technologies were considered for the advanced water treatment requirements of Alternatives 8a, 10a, and 13a.

1. Membrane Treatment with Zero Liquid Discharge (ZLD) for Concentrate Disposal

The membrane treatment process includes the following primary processes: sedimentation, low-pressure membrane pre-treatment, reverse osmosis, advanced oxidation (process with ultraviolet and hydrogen peroxide), disinfection, and followed by ZLD components for residual disposal. (Refer to the discussion below under Membrane Advanced Water Treatment Facility for further details.)

2. Non-membrane Treatment with Solids Drying Bed Waste Disposal

The non-membrane treatment process includes bank filtration, softening, filtration, advanced oxidation process with ultraviolet and hydrogen peroxide, and disinfection. Residuals would be concentrated using solids drying beds. This treatment would be similar to the concept planned by the City of Aurora for its Prairie Waters Project, but modified to address different source water characteristics and water uses for the Moffat Collection System.

Both types of plants would be configured to remove or reduce target adverse water quality constituents by treatment process or by blending of water from the South Boulder Diversion Canal.

These two technological approaches bring advantages and disadvantages related to their integration in the Moffat Collection System. The membrane system offers reliable treatment of the targeted contaminants and reduces TDS effectively, but preservation of the membranes may be an issue for prolonged plant shutdowns. ZLD has not been widely used in the municipal water sector and its operation is complex and expensive. The non-membrane technology provides relatively reliable treatment of the targeted contaminants, except for TDS (which would require blending to meet EPA secondary TDS limits), but also requires a large footprint (plant and other associated facilities including bank filtration). This type of plant is also difficult to start up after shutdowns due to the biological processes that are involved. Figures C-1 through C-4 in Appendix C present the process schematics for both the membrane and non-membrane systems.

Based on an EIS-level independent review of the treatment technologies, the membrane system was selected for analysis in tandem with Alternatives 8a, 10a, and 13a, since the membrane advanced water treatment technology would produce higher water quality for the Moffat WTP, with fewer risks and reliability concerns, and would require considerably less land for the facility (approximately 80 acres versus 200 acres) (Boyle 2008a).

Membrane Advanced Water Treatment Facility – A preliminary site plan for the membrane system is shown on Figure C-5 in Appendix C (Boyle 2008b). Raw water from the South Platte River would be treated at the AWTP and delivered to the Moffat Collection System delivery point. The waste stream from the advanced water treatment process would be disposed of through the ZLD process, in which all water is removed from the brine and the solids properly disposed of. The water is removed using solar evaporation ponds and solids drying beds, and the dried solids disposed of through a private disposal company or at a monofill (a specialized landfill with segregated cells for only these materials). (Refer to the discussion under Alternative 8a [Section 2.5.2] and Alternative 13a [Section 2.7.2] for a specific description of the proposed advanced water treatment facilities.)

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2.3 PROPOSED ACTION

2.3.1 Introduction/Abstract

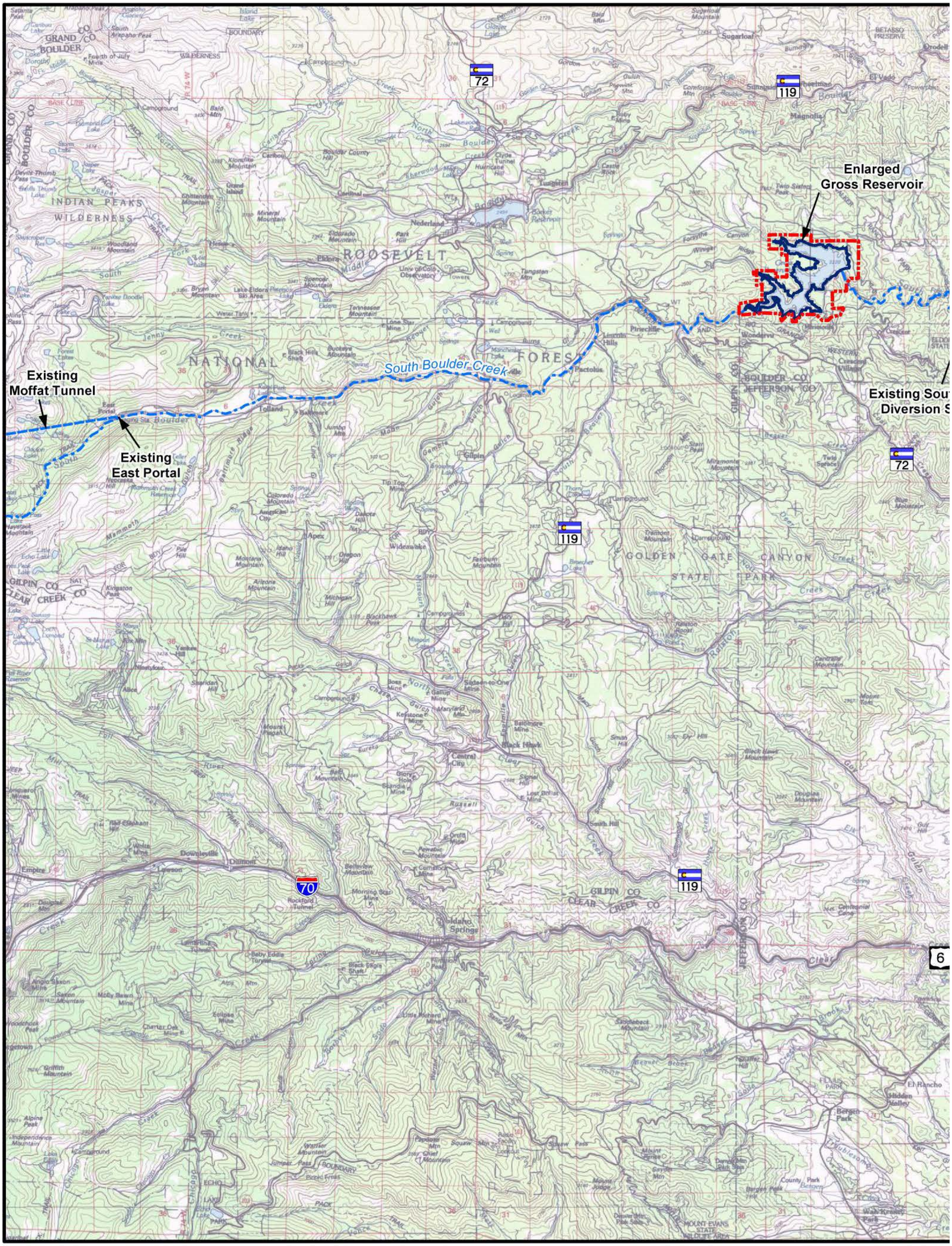
Using existing collection infrastructure, water from the Fraser and Williams Fork river basins, and South Boulder Creek, would be diverted during average and wet-years and delivered to an enlarged Gross Reservoir. In order to firm this water supply and provide 18,000 AF of new yield, the existing Gross Reservoir would be expanded from 41,811 to 113,811 AF to provide an additional 72,000 AF of storage capacity. In addition, Denver Water proposes to create an additional 5,000 AF of storage in the reservoir in order to store water that would be used in flow releases to enhance aquatic habitat in South Boulder Creek. This additional storage is identified as the Environmental Pool throughout this document. Existing facilities would be used to deliver water from the Gross Reservoir Expansion to the Moffat WTP, including the South Boulder Diversion Canal and Conduits 16 and 22. Figure 2-2 displays the Proposed Action components from the East Portal of the Moffat Tunnel east to the Moffat WTP.

Table 2-10 lists the major components of the Gross Reservoir expansion and dam raise.

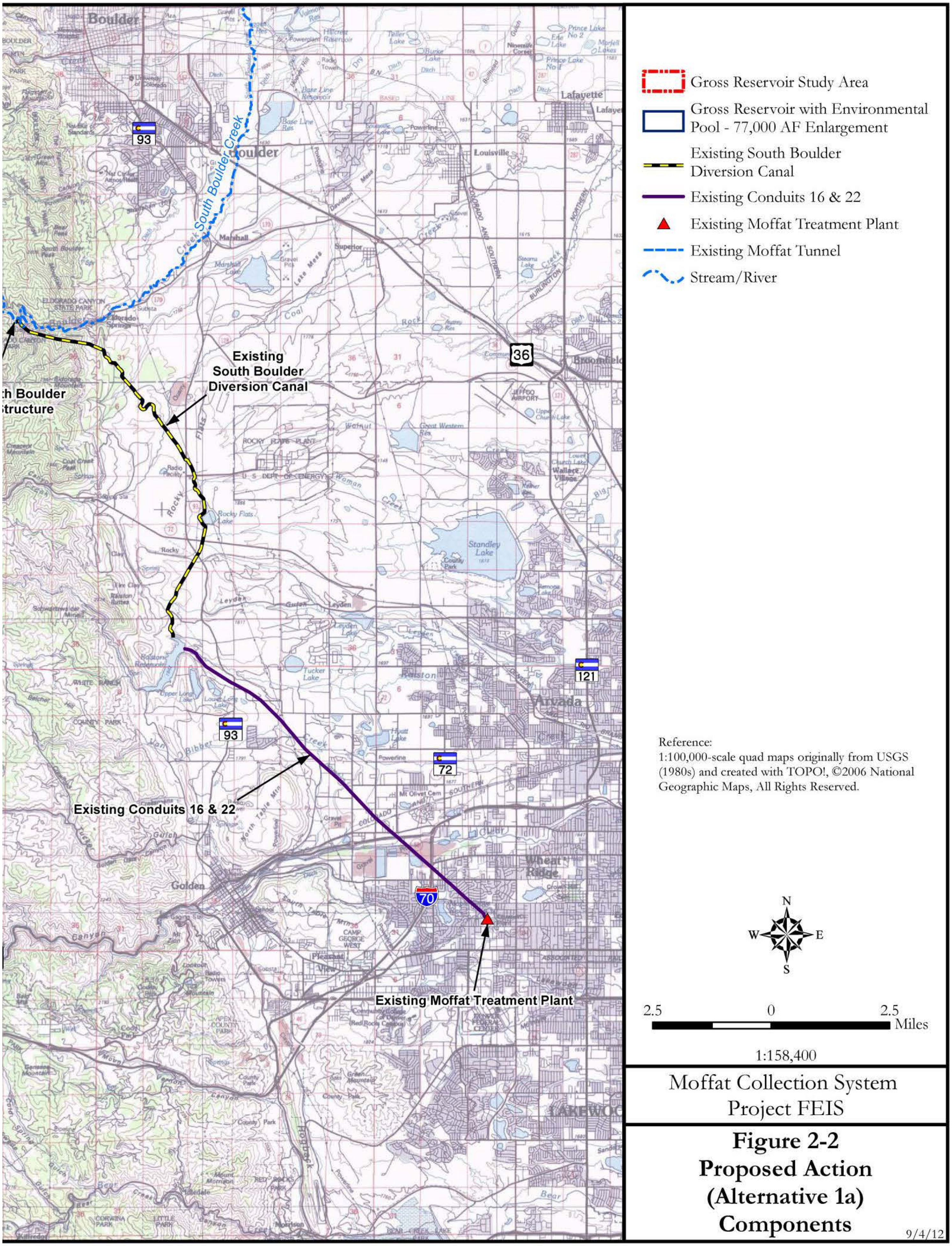
Table 2-10
Proposed Action (Alternative 1a) – Primary Components

Facility	Component Description
Gross Reservoir Expansion and Dam Raise	Additional 77,000 AF of storage capacity, including the 5,000 AF Environmental Pool for mitigation
	131-foot dam raise, including the 6-foot raise for the Environmental Pool for mitigation
	New concrete spillway over dam raise
	New auxiliary spillway south of dam
	Four construction staging areas
	Relocation of existing recreation and visitation facilities
	Borrow material: approximately 60% of the total borrow material produced on site; up to 40% of fine aggregate obtained from off-site commercial sources
	Relocation of existing dam and spillway access roads
	Two stockpile and two spoil areas and associated haul roads
	No modification to existing outlet works

Notes:
% = percent
AF = acre-feet



Enlarged
Gross Reservoir
Existing
Moffat Tunnel
Existing
East Portal
South Boulder Creek
ROOSEVELT
NATIONAL
FORES
GOLDEN GATE CANYON
STATE PARK
72
119
70
6



Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Moffat Collection System Project FEIS

Figure 2-2
Proposed Action (Alternative 1a) Components

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2.3.2 Project Components

2.3.2.1 Gross Reservoir

Gross Reservoir, owned and operated by Denver Water as part of its municipal water supply system, is located in Boulder County, Colorado, approximately 35 miles northwest of Denver and 6 miles southwest of the City of Boulder. The Gross Reservoir study area is shown in Figure 2-3. Figure 3.16-1 in Chapter 3, shows land ownership boundaries in the vicinity of Gross Reservoir. Lands within the study area boundary are primarily owned by Denver Water and the U.S. Forest Service (USFS). Approximately 15 acres of private land would have to be acquired by Denver Water to enlarge Gross Reservoir. Denver Water owns and operates Gross Reservoir as part of its overall municipal water supply system.

Gross Reservoir, an impoundment of South Boulder Creek, serves as a water storage and regulating facility by collecting snowmelt runoff in the late spring and early summer for domestic use during the remainder of the year. The existing Gross Reservoir stores 41,811 AF, and has a surface area of 418 acres and a shoreline of approximately 11 miles at an elevation of 7,282 feet (spillway elevation). Under the Proposed Action, Gross Reservoir would be expanded to 118,811 AF in order to provide an additional 77,000 AF of storage with the Environmental Pool for mitigation. The proposed reservoir surface area at normal water level (elevation 7,406 feet) would expand to approximately 842 acres, with approximately 14 miles of shoreline.

Currently, there is negligible seepage at Gross Dam and this is not expected to change significantly under the Proposed Action. Figure 2-3 shows the extent of the proposed Gross Reservoir Expansion to 77,000 AF with the Environmental Pool. Gross Dam and Gross Reservoir are features of the Gross Reservoir Hydroelectric Project, FERC Project No. 2035. An expansion of Gross Reservoir would require Denver Water to receive approval for an amendment to the March 16, 2001 license for the Gross Reservoir Hydroelectric Project (Denver Water 2001). Denver Water would also need to receive approval from FERC’s Division of Dam Safety and Inspections for any modifications to the dam structure or other licensed Project features. These issues are discussed further under the Gross Reservoir Hydroelectric Project License of Section 2.3.2.

Water Source

Long-term historic data suggest that approximately 45% of the inflow to Gross Reservoir comes from the South Boulder Creek Basin, and about 55% is diverted from the Colorado River Basin. Of the total inflow to the reservoir, the amount stored consists primarily of water diverted from the Colorado River Basin because the water supply originating in South Boulder Creek is typically called for by other downstream water users. Denver Water has water rights to both the imported West Slope water and some native South Boulder Creek water; however, Gross Reservoir is primarily used to store transbasin water delivered through the Moffat Tunnel. Denver Water’s South Boulder Creek rights are relatively junior in priority, so flows from South Boulder Creek are generally not available to Denver Water during dry years and are bypassed to downstream users. Water stored in Gross Reservoir is released and diverted to Ralston Reservoir via the South Boulder Canal. No new water rights or conveyance facilities would be required under the Proposed Action.

Under the Proposed Action, average and wet-year water would be supplied from the existing Moffat Collection System in the Fraser and Williams Fork river basins and to a lesser degree from South Boulder Creek. This additional supply would be collected and delivered using existing facilities. Water would be released from storage and delivered to Denver Water customers as needed.

Dam Features

Gross Dam is a 340-feet high, concrete gravity-arch dam with a crest length of 1,050 feet including a 160-foot long spillway section at an elevation of 7,282 feet mean sea level with the 2-foot high flashboards. The low-level outlet works consist of an intake trash-rack structure and an 8-foot diameter concrete-lined tunnel leading to an outlet works building located on the east bank of South Boulder Creek, about 250 feet downstream from the toe of the dam.

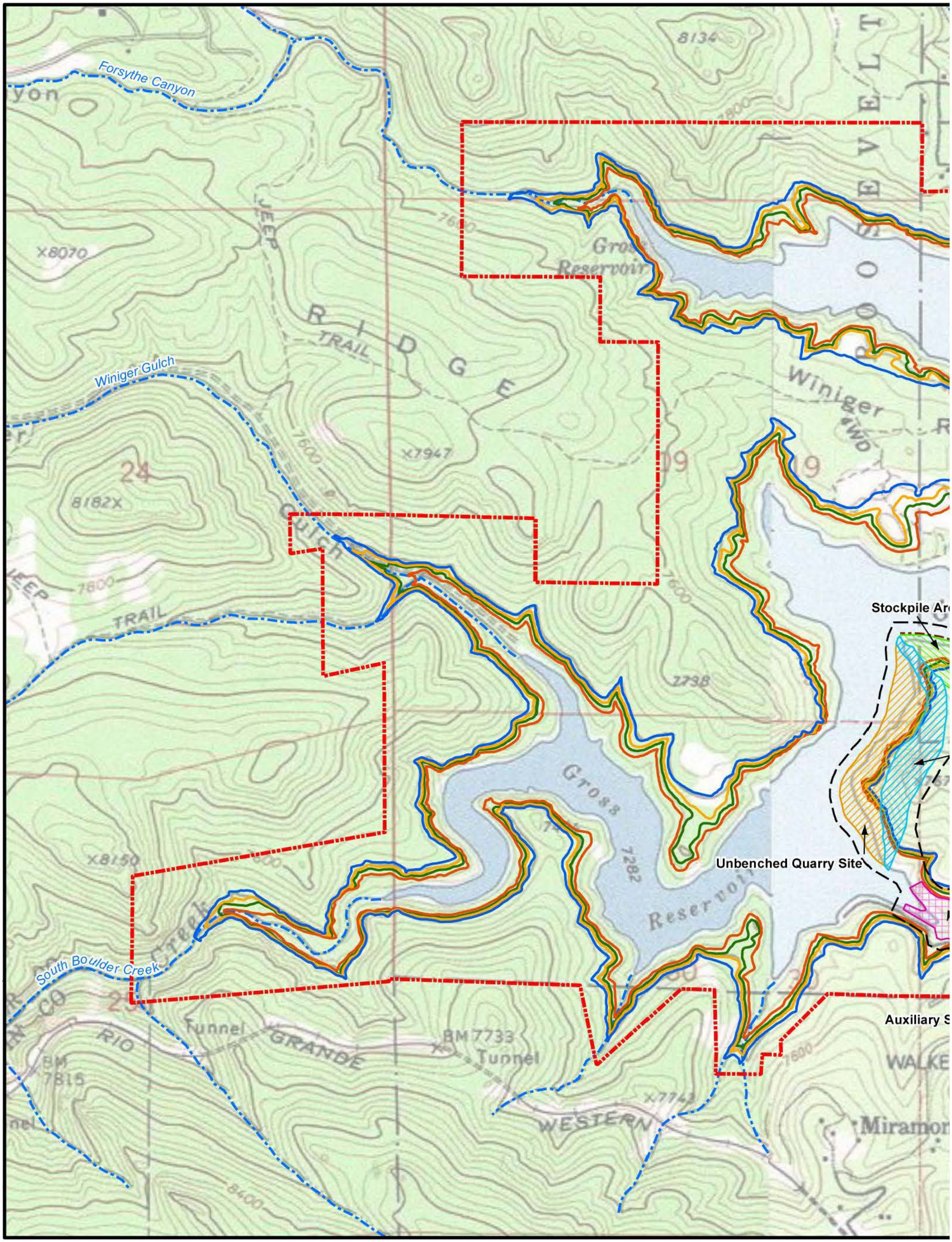
The existing dam was completed in 1954 as a concrete gravity-arch dam rising 340 feet above the streambed. The alignment of the existing dam in a narrow gorge was sited to facilitate a raised dam to a height of 465 feet. Under the Proposed Action, Denver Water would increase the dam's elevation by 131 feet, for a total dam height of 471 feet with a crest at elevation 7,406 feet mean sea level. This would allow storage of the additional 113,811 AF of water for municipal and industrial use, and the 5,000-AF Environmental Pool. The dam crest would be approximately 1,799-foot long and 25-feet wide. The raised dam would likely have approximately the same dam axis, arch radius, crest width, and downstream slope as the existing dam section.

Plans for the proposed 131-foot dam raise are conceptual and will be further developed based on permitting decisions by the Corps and FERC. Construction-related information such as the proposed spillway design, borrow and staging areas, concrete volumes, etc. is approximate based on conceptual-level designs, but is sufficient for purposes of the environmental analyses in this EIS.

Figure 2-4 shows the conceptual plan, profile, and sections of the enlarged dam. The upstream slope of the raised dam portion would be a vertical face. Table 2-11 provides a comparison of the proposed Gross Dam and Reservoir features with the existing facility.

Environmental Pool

Denver Water is proposing to create an additional 5,000 AF of storage in Gross Reservoir, as mitigation, to support environmental flow releases for enhancement of aquatic habitat downstream in South Boulder Creek. This additional storage would be filled with water provided by the cities of Boulder and Lafayette. None of Denver Water's existing or future water supply would be stored in this 5,000-AF Environmental Pool. To enable storage of additional water, Denver Water proposes to raise the dam an additional 6 feet beyond the proposed 125-foot raise necessary for increasing the storage of water, to a total height of 131 feet. The reservoir elevation during storage of the Environmental Pool would be 7,406 feet. The storage and release of water in the Environmental Pool would be managed under an Intergovernmental Agreement between Denver Water, Boulder, and Lafayette. Refer to Appendices H-22 and M-2 for additional information on the Environmental Pool.



Forsythe Canyon
Winiger Gulch
South Boulder Creek
Gross Reservoir
Stockpile Ar
Unbenched Quarry Site
Auxiliary S
RIDGE
TRAIL
JEEP
Winiger
Gulch
Gross
Reservoir
RIO GRANDE
WESTERN
Tunnel
BM 7733
BM 7815
WALKE
Miramon
8134
X8070
X7947
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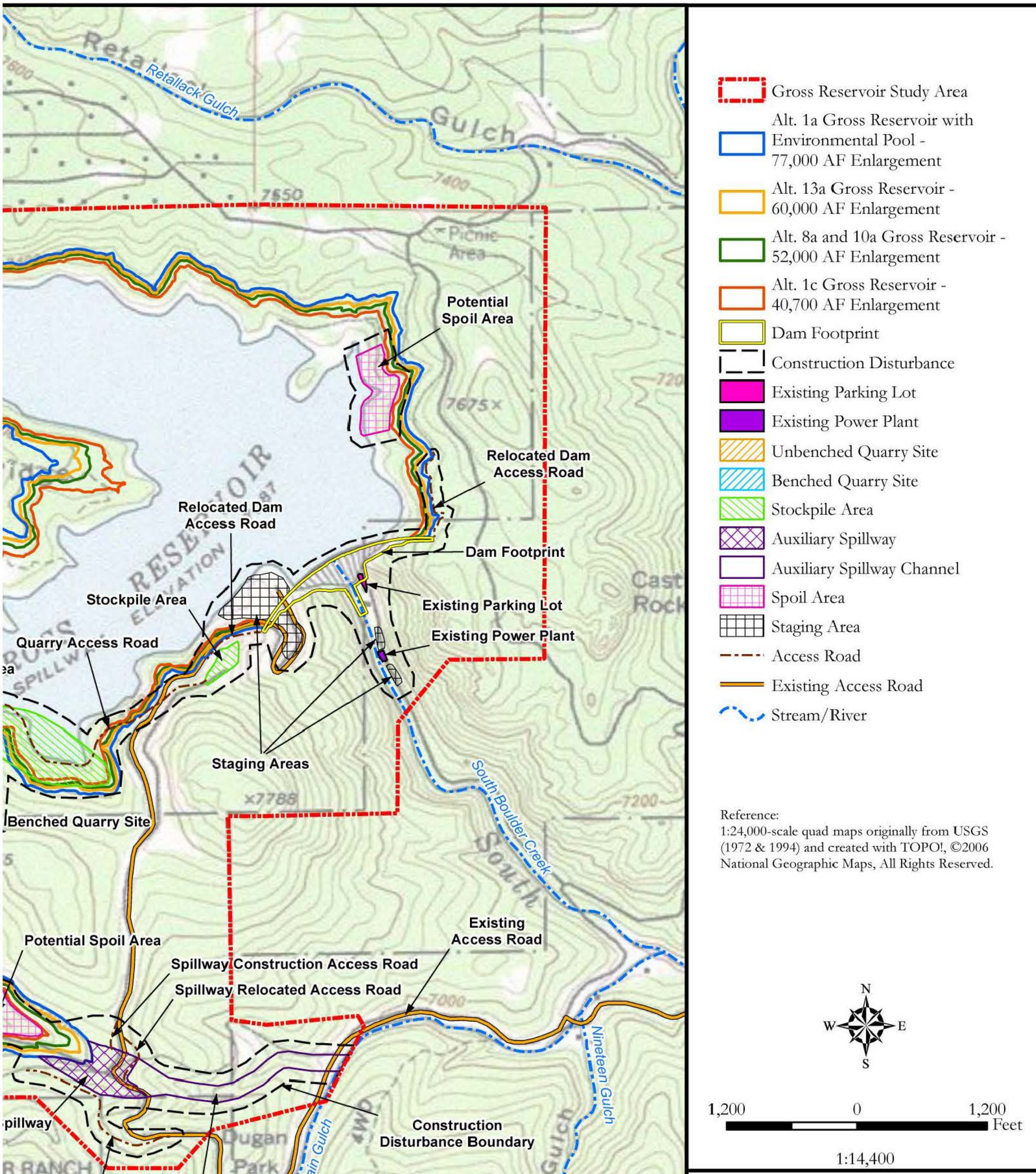

Moffat Collection System Project FEIS

Figure 2-3
Gross Reservoir Components

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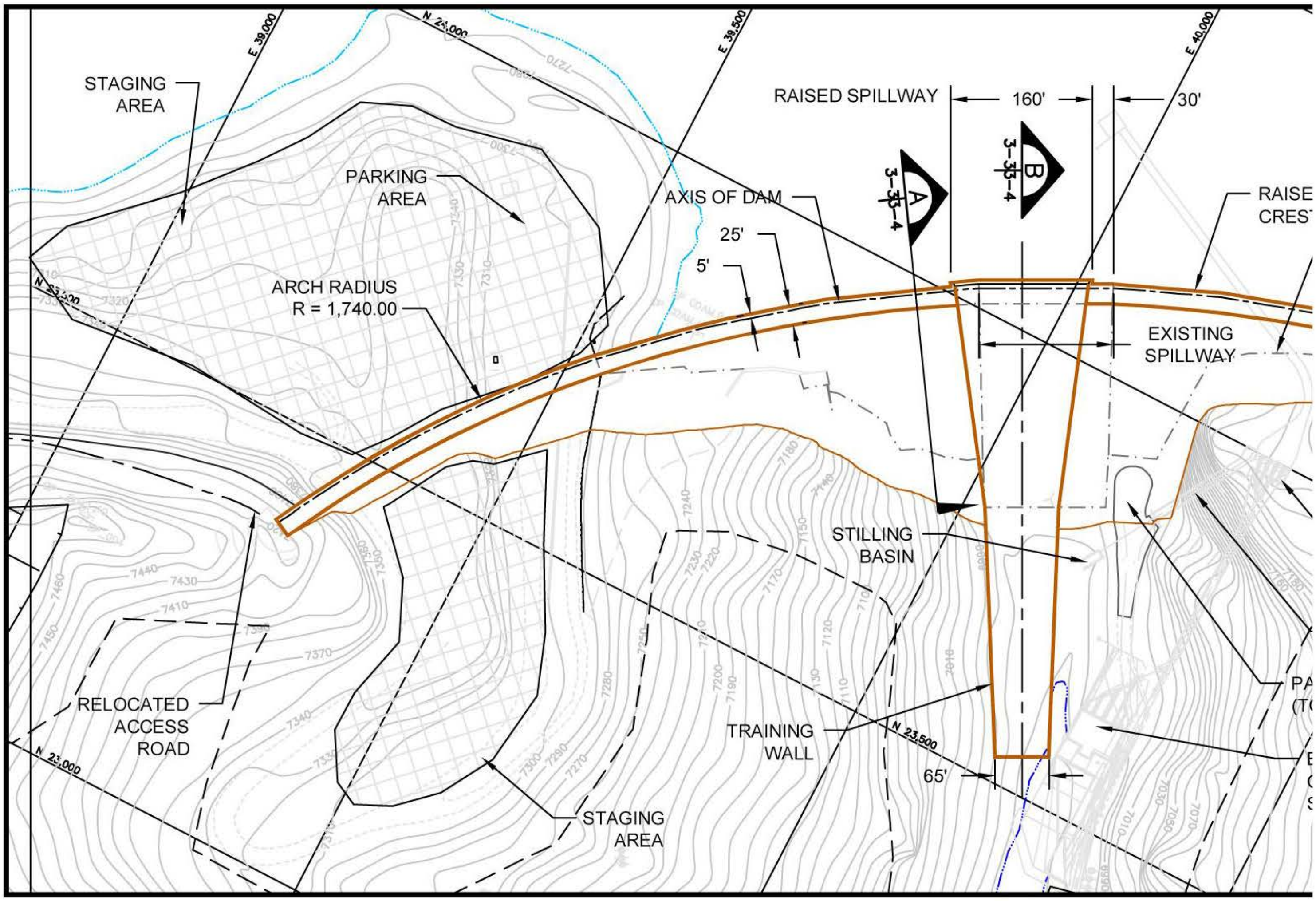


PLAN VIEW

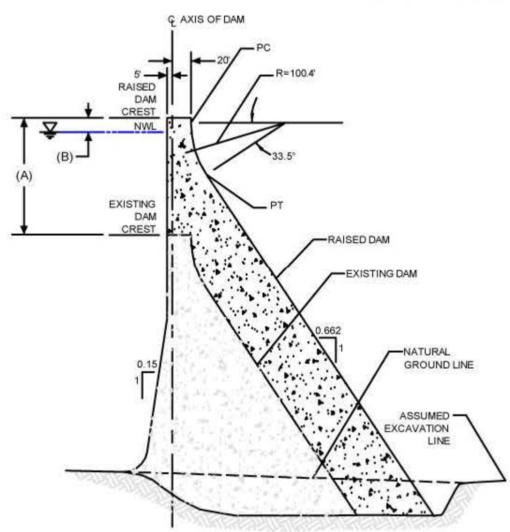
SCALE

100' 0 100' 200'

CONTOUR INTERVAL: 10 FT.

ALTERNATIVE	A (ft)	B (ft)
1a	125	15
1a[1]	131	15
1c	85	18
8a	101	16
10a	101	16
13a	110	15

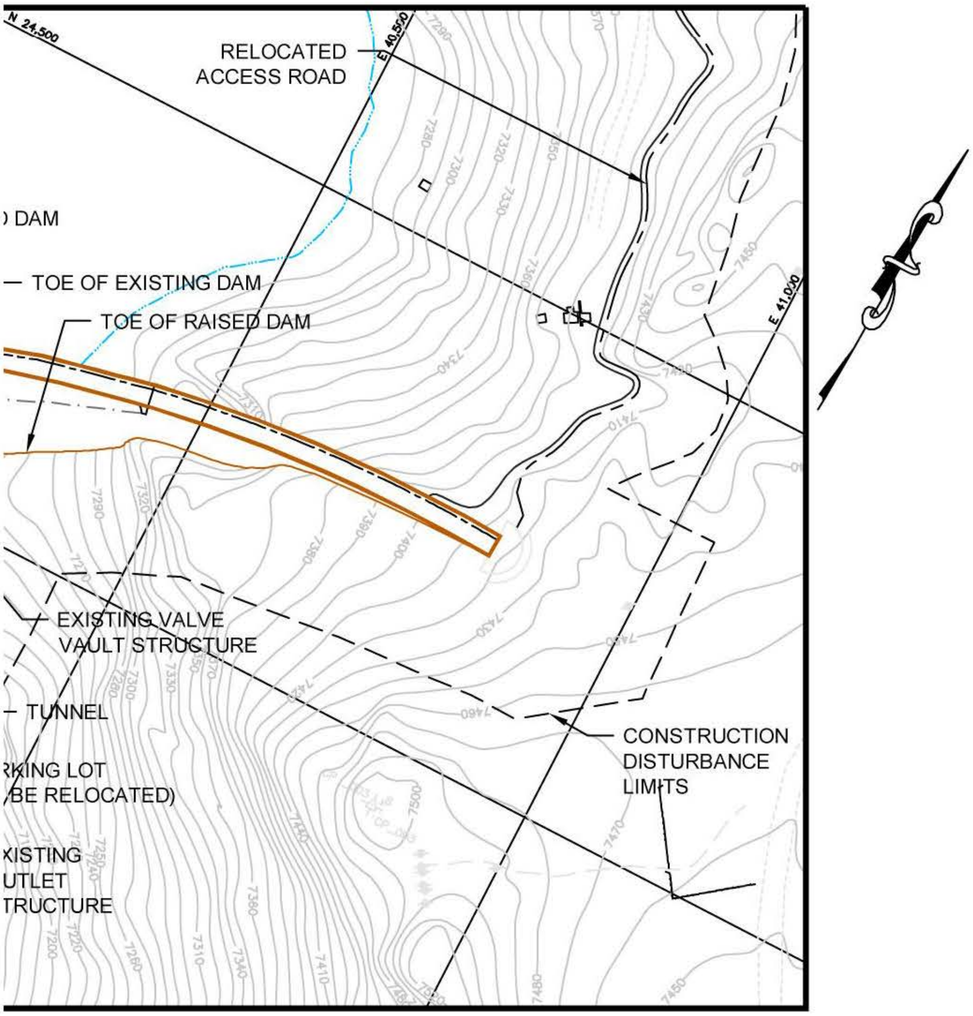
[1] with proposed mitigation storage of 5,000 acre-feet

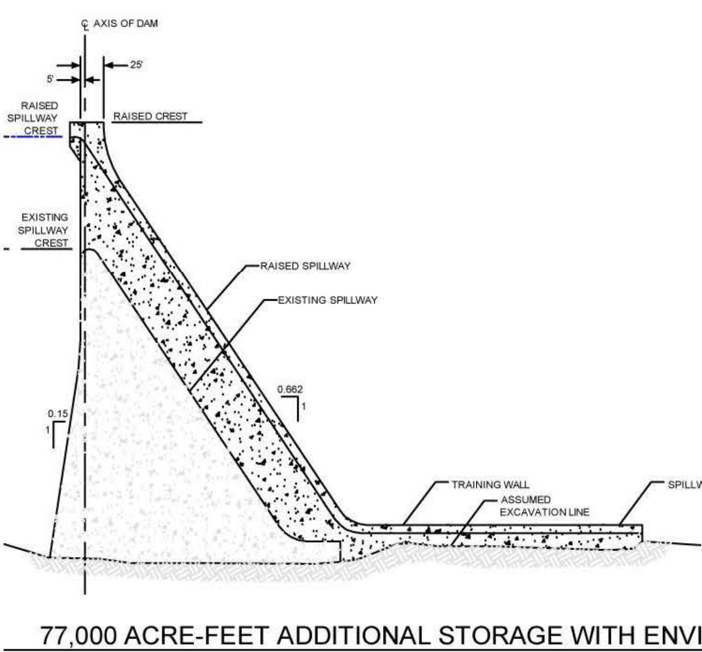


A 3-33-4 DAM PROFILE

0' 50' 100'
SCALE IN FEET

B 3-33-4





77,000 ACRE-FEET ADDITIONAL STORAGE WITH ENVIRONMENTAL POOL

0' 50' 100'
SCALE IN FEET

Note: All data provided by Denver Water (2006).

Moffat Collection System
Project FEIS

Figure 2-4
Gross Dam
Plan and Profile

5/16/13

Table 2-11
Comparison of Gross Dam and Reservoir Features* by Alternative

Gross Dam and Reservoir Features	Existing	Proposed Action (Alternative 1a)	Proposed Action with Environmental Pool	Alternative 1c	Alternatives 8a and 10a	Alternative 13a
Gross Reservoir						
Additional storage volume (AF)	--	72,000	77,000	40,700	52,000	60,000
Total storage volume (AF)	41,811	113,811	118,811	82,511	93,811	101,811
Normal water elevation (feet)	7,282	7,400	7,406	7,357	7,374	7,385
Surface area (acres)	418	818	842	651	712	755
Gross Dam						
Dam raise (feet)	--	125	131	85	101	110
Dam height (feet)	340	465	471	425	441	450
Crest length (feet)	1,050	1,799	1,840	1,640	1,708	1,753
Dam raise concrete volume (cy) (including spillway)	--	860,000	930,000	518,000	636,000	724,000
Spillway elevation (feet)	7,282	7,400	7,406	7,357	7,374	7,385
Auxiliary spillway	--	Added	Added	Same as 1a	Same as 1a	Same as 1a
Outlet works	Existing	No change	No change	Same as 1a	Same as 1a	Same as 1a

Source: Denver Water, 2001.
Notes:
*Dam features for all alternatives are estimates based on conceptual plans, and are subject to change based on final design.
AF = acre-feet
cy = cubic yard

Foundation Preparation and Excavation

Foundation preparation for the raised dam would include excavation of bedrock to shallow depths similar to the existing dam. An average of 30 feet of excavation is expected in the foundation area of the raised dam. Blanket grouting would be performed in the valley bottom to consolidate joints in the foundation, and the depth of the grout curtain would be increased by up to approximately 125 feet.

Spillways

The existing spillway is an uncontrolled, ogee-crested section located in the center of the dam. It passes flows down the recessed downstream face of the dam into South Boulder Creek. The existing spillway is at elevation 7,282 feet, including 2 feet of flashboards, and has a length of 160 feet. The spillway terminates in a horizontal apron at the downstream toe of the dam.

In order to satisfy current dam safety criteria, the new dam raise would require increased spillway capacity, improved dam safety conditions, and the construction of an enlarged service spillway. The proposed service spillway, similar to the existing spillway, would be incorporated into the raised section of the dam and would be designed to operate for the more frequent flood events.

An auxiliary spillway would also be constructed to convey flood flows in excess of the service spillway capacity, up to the probable maximum flood. The exact configuration and location of the auxiliary spillway would be developed during final design and could be located in the dam crest or in a topographic saddle south of the dam.

For purposes of the EIS, it was assumed that the auxiliary spillway could consist of a concrete weir structure constructed in the saddle approximately 1 mile south of the Gross Dam as shown in Figure 2-3. A rough channel would be graded southeasterly from the auxiliary spillway to direct spillway discharge away from the weir structure. The channel would be covered with riprap.

Inlet and Outlet Works

Because Gross Reservoir is an on-channel reservoir, an impoundment of South Boulder Creek, it has no special inlet works. No new inlet works would be required with the implementation of the Proposed Action.

Water is released from the reservoir through submerged lower level outlet works consisting of an intake, tunnel, conduits, and a valve house located downstream of the spillway apron. Water is released onto a reinforced concrete splash pad. The discharge valves have a combined discharge capacity that ranges from 0 to 3,000 cubic feet per second (cfs). Denver Water tries to maintain a minimum discharge of 5 cfs from May through October and 7 cfs from November through April throughout its operation of the outlet works (Denver Water 1998a). The existing outlet works were designed for the hydrostatic conditions associated with a dam enlargement. If the Proposed Action is implemented, the existing outlet works are capable of providing releases to satisfy all downstream water rights, meeting existing and proposed water supply requirements of Denver Water, and meeting reservoir storage evacuation requirements as required by the Colorado State Engineers' Office (the ability to evacuate the top 5 feet of the reservoir storage in 5 days). Prior to construction activities, Denver Water would verify if the existing discharge valves are sufficient for the new hydrostatic conditions.

Additionally, the low level outlet works and tunnel, mentioned above, is bifurcated and water can be released either from the discharge valves or a hydroelectric facility (powerhouse). The powerhouse consists of two horizontal Francis turbines, two synchronous generators, and associated mechanical and electrical equipment.

The new service spillway outlet chute would extend to the vicinity of the existing outlet structure; therefore, no modifications to the existing outlet works or powerhouse are expected. However, a pressure reducing valve (PRV) would need to be installed in an existing valve vault upstream of the powerhouse in order for the existing Francis turbines and generators to be used when the enlarged reservoir is full.

Borrow/Embankment Materials

The majority of the aggregate required to construct the raised dam would be excavated and processed on site. Fine aggregates (sand-sized fraction) may be difficult to produce on site; therefore, supplemental material may be needed from alternate off-site sources.

Suitable borrow material for the majority of the required construction is available on site in the reservoir area upstream of the dam. The rock knob north of the existing boat ramp has been identified as the primary aggregate borrow site. Alternative quarry sites may be considered, if needed, based on core drilling and laboratory testing, which would be conducted during the design phase. The primary quarry site would be located on the southeast shore of the reservoir, north of the proposed auxiliary spillway (Figure 2-3). This site is sized to produce at least twice the volume of aggregate required for construction. The east half of the quarry would be mined using benched slope construction; the west half would be an un-benched quarry excavation. A portion of the quarry would be situated below the existing normal water line of the reservoir, Quarry excavation below the normal water line would occur as the reservoir is lowered during normal operation. Denver Water intends to operate the reservoir in accordance with normal operating procedures during construction.

Post-construction, a portion of the quarry would be exposed bedrock in a benched slope formation. For planning purposes, this would consist of a cut slope approximately 200 feet high at 20% grade with a series of horizontal benches cut across the face of the slope. Pursuant to its existing FERC license, Denver Water would develop and seek approval from the USFS on any ground-disturbing actions that occur on National Forest System land. Additional license articles may be added during the FERC amendment process requiring Denver Water to develop and consult with specified resource agencies on a quarry mitigation plan to minimize the effect of the exposed quarry. The mitigation plan would consider a range of techniques, such as rock sculpting (shaping the exposed rock to mimic a natural rock face) and selective planting to break up the scale of the exposed area and soften the contrasts with adjacent areas. The use of rock staining would also be considered, provided a determination by Denver Water that its application would not create any water quality concerns. Denver Water currently has an Erosion Control and Rehabilitation and Restoration Plan per Articles 401 and 405 of the FERC hydropower license.

The majority of material would be produced prior to the start of construction; therefore, relatively large stockpile areas would be necessary for processing and temporary storage. As shown on Figure 2-3, two tentative stockpile areas have been identified on site: one is adjacent to the quarry site and the second is located west of the dam. The exact size and location of the stockpile areas would be identified during final design; wetland/riparian areas and other sensitive ecological areas would be avoided. Material from the quarry would be transported to the dam construction site via a proposed temporary haul road or along the haul road via a conveyer system. This road would be a gravel road approximately 30 feet wide. The haul road and stockpile areas that are located above the proposed high waterline would be restored to their approximate original condition post-construction.

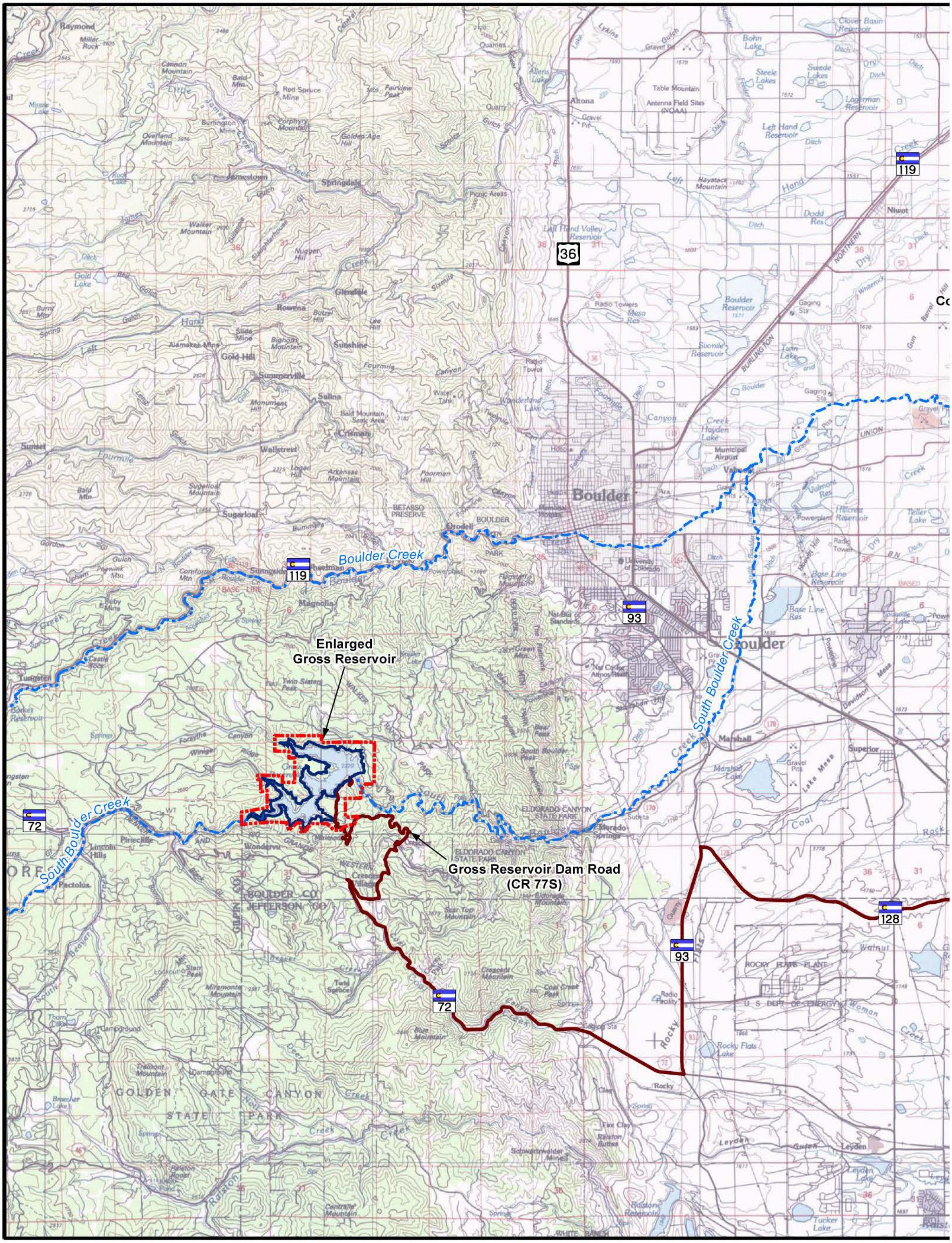
Processing the borrow material would require rock crushing and size sorting at a rock-processing operation to be located at the large stockpile area. It is assumed that the rock-processing facilities would likely be powered by a series of six or seven 125 to

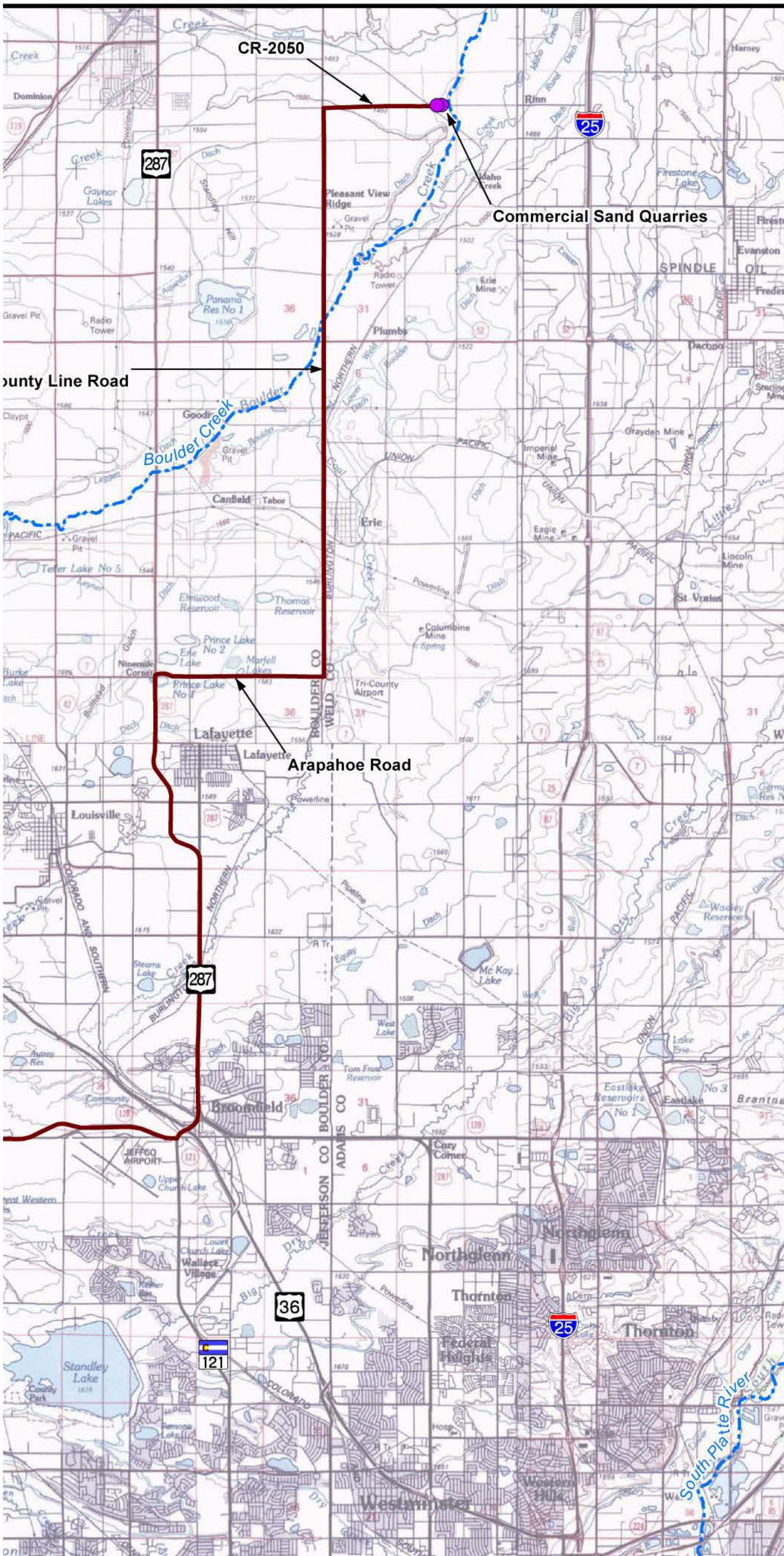
150 horsepower diesel engines and engine-generator sets. Aggregate production would likely precede concrete production with aggregate stockpiled for several months before use. This would allow aggregate production to occur primarily during the day; however, extended operations, up to 24 hours per day, could possibly be required at times. The cost and space requirements of producing sand-sized material on site are very high. Therefore, 40% of the preliminary volume of the dam is assumed to be imported to the site. In addition, flyash and cement would be transported to the site for concrete production. Imported material would be obtained from one or more commercial Front Range suppliers. For purposes of EIS analysis, it is assumed that the commercial suppliers would be in the Longmont area, such as LaFarge (Martin Marietta) or Aggregate Industries (Figure 2-5). Round trip haul distances from the potential commercial borrow sources are approximately 96 miles.

A temporary concrete production plant would be located at Gross Dam and would include equipment to handle, store, and mix aggregate, cement, water, and flyash to produce concrete. The plant would include up to four standard 12 cubic yard (cy) concrete mixers and approximately six 100 horsepower diesel engines and engine-generator sets to power the equipment. The plant would likely be operated up to 24 hours per day during the approximately April through November concrete placement period. All of the cement and flyash would be hauled to the site. For purpose of the EIS, the same route used to haul fine aggregate to the site was assumed to be used for transportation of cement and flyash.

Two potential spoil areas would be located due north and south of the dam site (4.8 acres). The exact size and location of the spoil areas would be identified during final design; wetland/riparian areas and other sensitive ecological areas would be avoided. During construction, access to the spoil areas would be from existing roads. Post-construction, both spoil areas would be situated entirely below the proposed high water level. Spoil areas would potentially contain excavation material and material not used for dam construction.

Blasting would occur when onsite aggregate quarries are in operation and in the early phases of construction related to the dam foundation excavation. Typically the frequency of blasting would be every 3 to 4 days due to the time it takes to drill the blast holes. Blasting would occur only during daylight hours. Safety precautions would be taken to keep unauthorized personnel away from blast areas. Blasts would be designed such that holes are appropriately spaced, loaded and stemmed to prevent air blast, excessive vibration and to limit any fly rock migrating outside of the blast zone. The blasting agent used would likely be ANFO (Ammonium Nitrate Fuel Oil), which when handled appropriately is a relatively safe and stable product used in construction and quarrying operations throughout the U.S. The blast would be designed to produce relatively low vibrations (ground motions) and blasting adjacent to the dam would be controlled to prevent any damage to the dam or the existing foundation. Blasting would be done by a blaster licensed in the State of Colorado and each blast would be designed by a licensed Blasting Engineer. Blasting would be designed specifically for Gross Dam and would create ground vibrations and land motion appropriate for the dam structure to sustain. A seismograph would be used to monitor ground motions and air pressure (noise) vibrations produced from the blasting operations to ensure that acceleration thresholds are not exceeded.


Enlarged
Gross Reservoir
Gross Reservoir Dam Road
(CR 77S)
Boulder Creek
South Boulder Creek
Boulder
36
119
93
72
128



Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

2.5 0 2.5 Miles

1:142,000

Moffat Collection System Project FEIS

Figure 2-5
Potential Aggregate Haul Routes

9/4/12

Support Facilities/Staging Areas

Several temporary staging areas have been identified at the reservoir site. For example, two staging areas are downstream of the dam site on South Boulder Creek. Two additional staging areas are located at the southwestern end of the dam. The staging areas adjacent to the dam and those that would be located near the hydropower plant are associated with the proposed dam construction footprint (refer to Table D-1 in Appendix D). The concrete plant, job trailers, and equipment yard would be located here. Existing slopes would be terraced to accommodate this. All staging areas are temporary disturbances and would be restored to their approximate existing conditions following construction.

Tree Removal Options

In order to minimize problems with floating debris, decaying vegetation and water quality concerns, all trees would be removed within the area of proposed inundation. It is assumed trees would be removed between the existing normal pool elevation (7,282 feet) and 7,410 feet, which is 4 feet above the proposed normal pool elevation. Vegetation along the shoreline is primarily forest cover containing ponderosa pine and Douglas-fir, the density of which ranges from approximately 150 to 1,800 trees per acre (Land Stewardship Associates, LLC 2008). Limited access to the shoreline, steep slopes (20% to greater than 60%), and large rock outcrops complicate tree removal at Gross Reservoir. Tree removal would likely require a combination of the following three standardized operations (Land Stewardship Associates, LLC 2008):

1. Ground-based systems (e.g., hand-felling with rubber-tired grapple skidder and cable yarding). These systems would be used in areas where existing roads are in place or where temporary road construction is feasible along the shoreline.
2. Helicopter yarding of cut trees. This would be conducted in areas where road access is not currently available or possible to construct.
3. Hydro-ax feller/buncher (rubber-tired tractor). Hydro-axing would be used in areas with poor access, small trees, steep slopes, and heavy rock such as the upper reaches of Forsythe Canyon. The hydro-ax would maneuver around rocky areas and reduce the trees to small pieces that would readily decay.

Denver Water would consult with the USFS before removing any timber from the National Forest System land.

The limited access to the Gross Reservoir shoreline would require the construction of several temporary access roads within the area to be cleared. Additionally, improvements to some existing roads at the reservoir are needed to accommodate the heavy equipment required for tree removal. Winiger Ridge would be used as a staging area for tree removal. The main access points would include State Highway (SH) 72, Gross Dam Road, and across Winiger Ridge using Forest Road (FR) 359 and County Road (CR) 68.

Residue Disposal

Approximately 50,000 tons of forest residue would be generated from clearing at Gross Reservoir. Since a traditional slash pile and burn approach to disposing the residue is not viable at Gross Reservoir due to air quality concerns and regulations, three possible alternative forest residue disposal options or combination of options would be implemented:

1. Burning in an air curtain destructor.
2. Grinding whole trees and hauling to a landfill.
3. Loading forest residue into trucks and hauling to a landfill.

Some of the forest residue could also be turned into products (sawtimber, firewood, etc.) and the remaining unmerchantable material would be disposed of by a combination of the three options. Opportunities to utilize some of the material to reduce the residue volume would be explored by Denver Water. Tree removal and disposal would take approximately 6 to 8 months to complete (Land Stewardship Associates, LLC 2008).

Roads and Access

Gross Reservoir can currently be accessed from Boulder via Flagstaff Road (CR 77), as well as via CR 68 and CR 97E, which turns into FR 359 (Figure 3.12-1). Denver Water has committed that trucks hauling materials associated with mass concrete placement would be restricted from using Flagstaff Road. Numerous road segments would need to be abandoned and relocated or newly constructed in order to facilitate construction operations at Gross Reservoir. Road segments would need to be relocated out of the proposed reservoir inundation boundary and out of the proposed footprints for the dam enlargement and spillway facilities.

Access to the dam would be available using the existing access road. However, minor road relocations at the north and south dam abutments would be necessary.

Permanent Roadway Relocations

Auxiliary Spillway – A portion of the existing Project access road would be relocated in two locations around the proposed auxiliary spillway in the saddle approximately 1 mile south of the Gross Dam as shown in Figure 2-3 (Spillway Relocated Access Roads). The relocated road characteristics would be similar to the existing road with gravel surface and a disturbance area of approximately 30 feet wide and 2,300 feet long. Abandoned road segments above the new high water line would be reclaimed.

Gross Dam – North and south of the dam, two road segments would be abandoned due to inundation. Both of these segments, which provide access to the dam, would be relocated. Approximately 1,500 feet of the north abutment access road (Dam Relocated Access Road) would be relocated to the east at an elevation 100 feet higher than the existing access road. Approximately 1,500 feet of the south abutment access road (Dam Relocated Access Road) would be relocated south of the existing access road. Both relocated road segments would be gravel surfaced and approximately 30 feet wide.

Abandoned road segments above the new high water line would be restored using techniques such as re-grading and seeding. No other roads in the Project area would need permanent improvements.

Temporary Construction Roadways

Construction access would be obtained using existing roads. In addition, two temporary access roads would be constructed to provide hauling access between the quarry areas, stockpile areas, and the dam raise site. These roads include (1) a haul road (Quarry Access Road) between the quarry site and stockpile area (approximately 3,000 feet long), and (2) an access road (Spillway Construction Access Road) by the auxiliary spillway (approximately 300 feet long). The disturbance width would be 30 feet and the roads would be gravel surface. Post-construction, the portion of the temporary roads remaining exposed above the normal reservoir water elevation would be restored and seeded.

Recreational Facilities and Public Access

Gross Reservoir currently has a water surface area of 418 acres and a shoreline of approximately 11 miles. The reservoir offers a number of recreation opportunities, including non-motorized boating, fishing, hiking, picnicking, wildlife viewing, bicycling, camping, ice fishing, horseback riding, off-highway vehicle riding, 4-wheel driving, and nature viewing. Swimming and discharging firearms are illegal on site. Non-motorized car-top boating was allowed beginning in the summer of 2005. Additionally, the Gross Reservoir Recreation Management Plan (Article 416 of the FERC License) (Denver Water 2004b) is being implemented throughout the study area.

Nine recreation sites exist in the Gross Reservoir vicinity:

- North Shore Recreation Area
- Peninsula Recreation Area
- Dam Recreation Area
- South Boulder Creek Outlet
- Haul Road Recreation Area
- South Boulder Creek Inlet
- Winiger Gulch Inlet
- Winiger Ridge Access & Recreation Area
- Rocky Point/Jumping Rock

Refer to Section 3.15 for more details about the facilities. With the exception of the North Shore Recreation Area, South Boulder Creek Outlet, and Winiger Ridge Access and Recreation Area, all recreation sites and facilities would be inundated with this alternative. These recreation facilities would need to be relocated to sites above the proposed high waterline.

Public Access

Public access to Gross Reservoir would not be changed under this alternative. Vehicle access would remain unchanged via the existing north and south access points. During construction, recreation access and facilities would be restricted or temporarily closed as needed to protect public safety and not compromise construction progress.

Reservoir Delivery Infrastructure

There would be no change to existing pipelines or other delivery infrastructure as a result of this alternative.

Reservoir Inflows

Water supplies would be delivered from the West Slope through the existing Moffat Tunnel and discharged to South Boulder Creek. From the Moffat Tunnel outlet portal, water would flow down South Boulder Creek to be stored in an enlarged Gross Reservoir. Native South Boulder Creek supplies would also be stored in Gross Reservoir or diverted directly at the

South Boulder Diversion Canal. There are no proposed modifications to this collection system.

Reservoir Outflows
Water is released from Gross Reservoir via South Boulder Creek and is diverted at the existing South Boulder Diversion Canal Diversion structure. Pursuant to an agreement between Denver Water and the City of Boulder, Denver Water has agreed to not divert South Boulder Creek native water during the months of November through March if those diversions would cause the flow to drop below 7 cfs downstream of the South Boulder Diversion Canal diversion point. Water diverted from South Boulder Creek is conveyed via the existing South Boulder Diversion Canal to Ralston Reservoir. Water is released from Ralston Reservoir to Conduits 16 and 22 and conveyed to the Moffat WTP.

Utilities, Lighting, and Fencing

There would be no change to the existing utilities or transmission lines. The raised dam would have the same lighting as existing conditions. The raised dam would be fenced and gated, like the existing dam, to prevent unauthorized access to the dam crest and outlet works.

Gross Reservoir Hydroelectric Project License

On February 27, 1951, the Federal Power Commission, FERC's predecessor, issued Denver Water a 50-year license for the Gross Reservoir Hydroelectric Project, Project No. 2035. Licensed Project features included Gross Dam and Gross Reservoir. However, power generation facilities were not installed, because of a lack of economic feasibility. On March 16, 2001, FERC issued Denver Water a new license for the Gross Reservoir Hydroelectric Project, which included approval for construction of generating facilities. A powerhouse with a hydraulic generating capacity of 7.6-megawatts was installed immediately downstream of the dam in 2007 to utilize flows released from Gross Reservoir for water supply purposes (Figure 2-3). In compliance with the requirements of articles in the 2001 FERC license, Denver Water implements the following environmental protection, mitigation, and enhancement measures at Gross Reservoir:

- Recreation management plan
- Erosion and sediment control plan
- Weed management plan
- Dissolved oxygen and temperature monitoring plan
- Ramping rate plan to control the allowable rate of flow changes to minimize impact to the fisheries
- Visual resource protection plan
- Power-line raptor protection plan
- Sensitive species surveys and protection plan

Denver Water's existing and proposed water supply operation at Gross Reservoir will not change to accommodate power generation. Power generation is considered incidental to the continued operation of Gross Reservoir for its primary purpose of water supply.

For the Proposed Action to be implemented, Denver Water would need to receive approval from FERC for an amendment of the Gross Reservoir Project license to expand the Project boundary and to modify other affected Project features and license article requirements, as necessary. Denver Water would also need to receive approval from FERC's Division of Dam Safety and Inspections prior to any modifications to Gross Dam. Obtaining approvals from FERC is a separate regulatory process from the Corps' Section 404 review. Denver Water has indicated that its application to FERC to amend the hydropower license for the Gross Reservoir project will reference sections of this Final EIS to provide environmental information required in the amendment process. Denver Water also holds FERC hydropower licenses for other facilities; none of which would have to be amended as a result of implementing a Moffat Project alternative.

2.3.3 Proposed Changes to Denver Water's System Operations

Reservoir Operation Plan

The current general operating plan for Gross Reservoir is to store and regulate water imported through the Moffat Tunnel and native flows from South Boulder Creek.

When Gross Reservoir storage is less than 12,000 AF, there is a dam safety problem of rocks and sediment being transported to the outlet works and resulting damage. In addition, the transported sediment could impact aquatic life in South Boulder Creek below the dam. For these reasons, the bottom 12,000 AF is a minimum pool that is not relied on for water supply purposes.

To avoid spilling, Denver Water reduces West Slope importations as Gross Reservoir is about to fill. Gross Reservoir typically stores the most water in June during spring runoff.

Denver Water's System Operations

The Proposed Action affects operations, diversions, and stream flow regime throughout Denver Water's system because of the relationship between the North and South system operations. The additional storage at Gross Reservoir, with an increase in demand of 18,000 AF/yr and changes in the Moffat WTP operations, would affect the amount of water in storage throughout Denver Water's system at certain times of the year, the timing and amount of reusable effluent, and the potential for Denver Water to exchange water up the South Platte River. The primary changes in Denver Water's North and South system operations under the Proposed Action are described below. (Refer to Section 1.3.1 for details on Denver Water's raw water collection system and Section 5.1 for details on the proposed hydrologic changes.)

Denver Water has three WTPs – Moffat, Marston, and Foothills – for which operations are coordinated to meet Denver Water's total demand. The Moffat WTP treats water supplied from Denver Water's North System while the Foothills and Marston WTPs treat water supplied from Denver Water's South System.

North System

Moffat Collection System – The following changes in Denver Water's Moffat Collection System operations would occur under the Proposed Action.

- Denver Water would divert more water from the Williams Fork and Fraser rivers with increased storage at Gross Reservoir. Denver Water's diversions via the Moffat Collection System would primarily be higher during average and wet years following a drought in order to fill additional storage at Gross Reservoir. During the winter months and dry years, there would be few differences in diversions and operations in this system.
- Denver Water's operations during the course of a drought would change with additional storage at Gross Reservoir. Denver Water would draw more water to meet demand from Gross Reservoir in the first year of a drought as it would from its other reservoirs. In advanced stages of the drought, Denver Water's South Platte reservoirs and Dillon Reservoir would get drawn on more intensely as Gross Reservoir storage is depleted.
- Denver Water would also divert more native South Boulder Creek water, either to storage at Gross Reservoir or at South Boulder Diversion Canal. More water would be released from Gross Reservoir for delivery to Moffat WTP particularly in the winter months because Moffat WTP would operate at a minimum level during those months. Denver Water would also release more water from Gross Reservoir to meet demand in the first year of a drought.
- Williams Fork Reservoir operations (storage and releases) would change. Less water would be available for storage due to increased diversions from the upper Williams Fork River tributaries. As a result, Williams Fork Reservoir would generally achieve fills later in the year and spill less. In addition, pre-emptive releases for power early in the year would be less because the reservoir would not be forecasted to spill as often. Discretionary power releases later in the year would also be less because reservoir contents would generally be lower.

Moffat Water Treatment Plant – The Moffat WTP treats water supplied from Denver Water's North System while the Foothills and Marston WTPs treat water supplied from Denver Water's South System. Moffat, Foothills, and Marston WTP operations are coordinated to meet Denver Water's total treated water demand. The Moffat WTP currently operates from April or May through October 15 at a minimum of 30 mgd, and is typically shut down the remainder of the year. Under the Proposed Action, the Moffat WTP would typically operate throughout the year, maintaining a minimum operation of 30 mgd. This change in Moffat WTP operations would result in a load shift between Denver Water's North and South systems WTPs.

South System

Roberts Tunnel Collection System – Under the Proposed Action, the Moffat WTP would typically meet a portion of the demand that would otherwise be met by Foothills and Marston WTPs during the winter months. Consequently, there would be a reduction in winter operations of Foothills and Marston WTPs and therefore, a reduction in diversions through Roberts Tunnel in those months. More water would remain in Dillon Reservoir and less water would generally be delivered through the Roberts Tunnel to the North Fork

South Platte River during the winter months. As a result, Dillon Reservoir would generally be at slightly higher levels at the beginning of the runoff season. Deliveries through Roberts Tunnel to the North Fork South Platte River would generally be higher during the summer months because the overall system demand would be higher and the seasonal shift in WTP operations described above. These seasonal shifts transfer some of the system demand from the South System to the North System during the winter and vice versa during the summer.

South Platte Collection System – In general, the following changes in Denver Water's South Platte Collection System operations would occur under the Proposed Action.

- Denver Water's operations during the course of a drought would change with additional storage at Gross Reservoir. Denver Water would draw more water to meet demand from Gross Reservoir entering a drought, which would reduce the demand on Antero, Eleven Mile Canyon, and Cheesman reservoirs and Denver Water's Blue River supplies. Consequently, less water would be released from Denver Water's South Platte reservoirs in the beginning stages of a drought. In advanced stages of the drought, Denver Water South Platte reservoirs and Dillon Reservoir would be drawn on more intensely as Gross Reservoir storage is depleted.
- The seasonal shift in WTP operations would affect releases from Denver Water's South Platte reservoirs. Less water would be released from Denver Water's South Platte storage during the winter months, because the Moffat WTP is meeting demand that would otherwise be met by Foothills and Marston WTPs during those months. Releases from storage would generally be higher in the summer months because the overall demand level would be higher and load shifting described above.
- The amount and timing of reusable effluent available at the Metro WWTP and Bi-City WWTP would change under the Proposed Action. There would be less reusable water available during the winter months and more reusable water available during the summer months due primarily to changes in the amount of Blue River water that would be used. Exchanges of reusable water to Strontia Springs Reservoir (Foothills WTP) and Conduit 20 (Marston Reservoir and Marston WTPs) would generally increase under the Proposed Action for the following reasons: (1) the available reusable effluent would increase during summer months because more water would be diverted through Roberts Tunnel from the Blue River Basin, and (2) Foothills and Marston WTPs would operate at higher rates under the Proposed Action because the overall level of demand would be higher.
- The timing and quantity of Denver Water's direct diversions at Strontia Springs Reservoir would change in response to the treatment plant load shift and the higher level of demand that would be met. Denver Water would shift some of its water treatment operations from Foothills and Marston WTPs to the Moffat WTP during the winter.
- Water would be moved between Strontia Springs, Chatfield, and Marston reservoirs differently under the Proposed Action due to the treatment load shift. The amount moved would be comparable to Full Use of the Existing System, but the timing of use would change.

Foothills and Marston Water Treatment Plants – Moffat, Foothills, and Marston WTP operations are coordinated to meet Denver Water's total treated water demand. Under the Proposed Action, the Moffat WTP would operate throughout the year, maintaining a minimum operation of 30 mgd. Because the Moffat WTP would operate at a minimum rate during the winter months, Denver Water's southern WTPs, which include Foothills and Marston, would operate less during these months. In the summer, Foothills and Marston WTPs would operate at higher rates under the Proposed Action because of the overall higher level of demand that would be met and load shifting as previously described.

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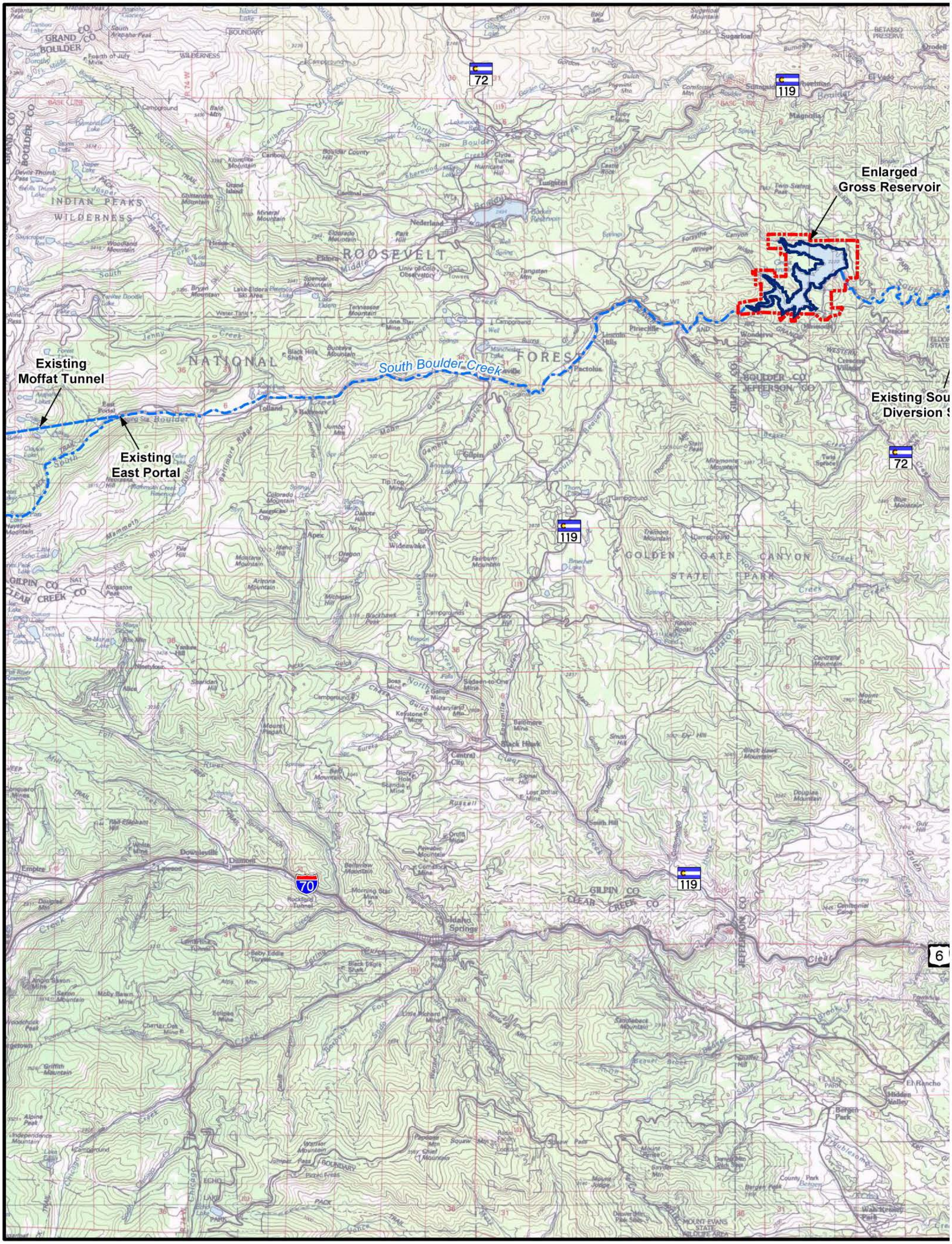
2.4 ALTERNATIVE 1C – GROSS RESERVOIR EXPANSION (40,700 AF)/NEW LEYDEN GULCH RESERVOIR (31,300 AF)

2.4.1 Introduction/Abstract

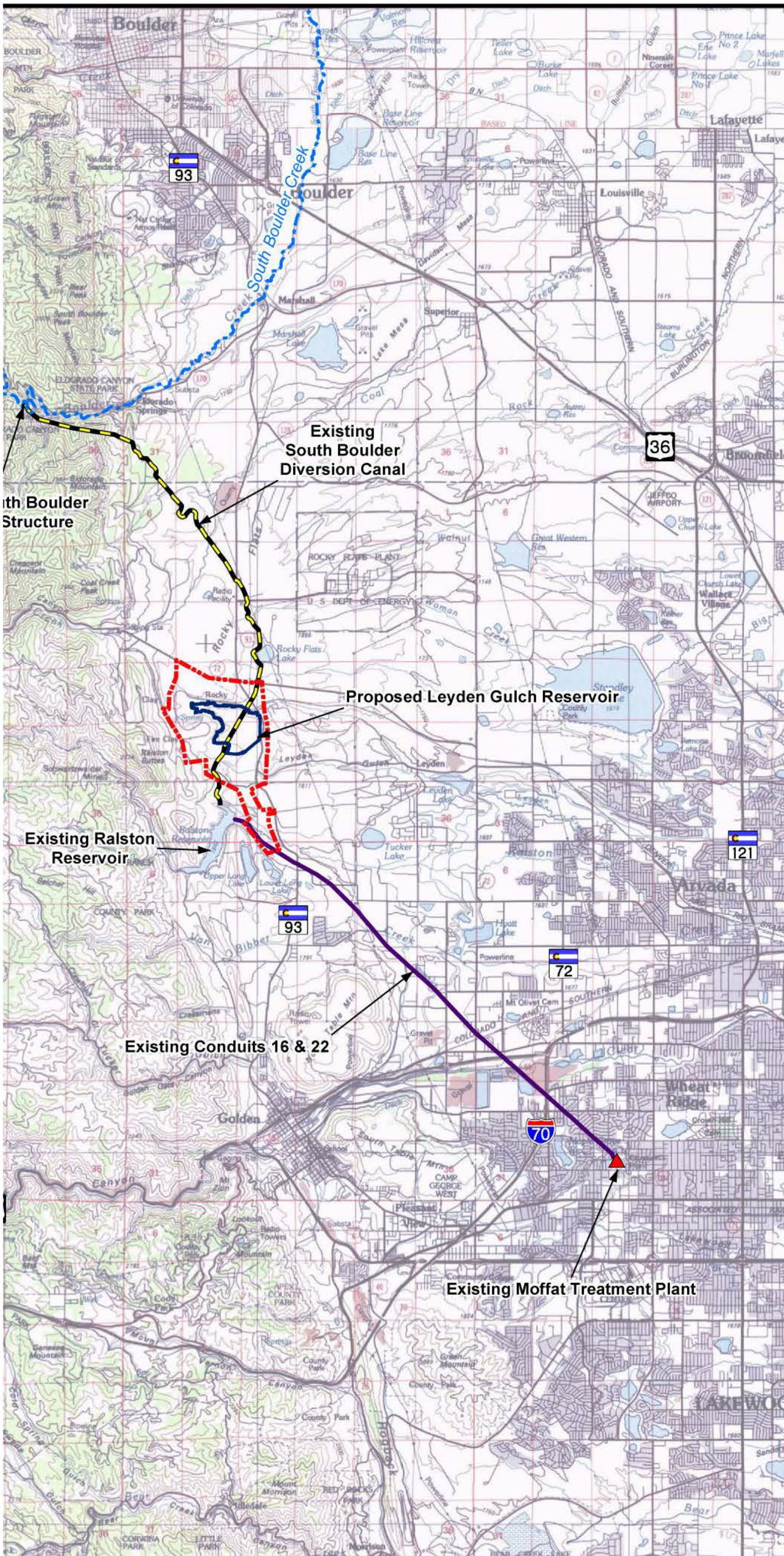
Alternative 1c would combine additional Moffat Collection System supplies and two reservoir storage facilities to provide 18,000 AF/yr of new firm yield. The existing Gross Dam would be raised 85 feet to provide an additional 40,700 AF of new storage capacity at Gross Reservoir. A new off-stream reservoir would be constructed in Leyden Gulch to provide 31,300 AF of active storage capacity. This combination of reservoir storage represents a balance of construction cost, relocation requirements, operational considerations, and potential environmental impacts based on existing information and analyses. If Alternative 1c were selected for implementation, the exact combination of storage sizes may vary, based on more precise design data, but would still total 72,000 AF of new reservoir storage.

Using existing Denver Water collection infrastructure, water from the Fraser and Williams Fork river basins and South Boulder Creek would be delivered during average and wet-years to an enlarged Gross Reservoir and then delivered via the South Boulder Diversion Canal to a new Leyden Gulch Reservoir. A combination of existing and new facilities would be used to deliver water from the enlarged Gross Reservoir and the new Leyden Gulch Reservoir to the Moffat WTP. Water would be released from storage and delivered to Denver Water customers when needed. Figure 2-6 displays Alternative 1c components from the East Portal of the Moffat Tunnel east to the Moffat WTP.

Table 2-12 lists the major components of the Gross Reservoir enlargement and the new Leyden Gulch Reservoir. Details are presented in the Project Components discussion below.



Enlarged
Gross Reservoir
Existing
Moffat Tunnel
Existing
East Portal
South Boulder Creek
Existing Sou
Diversion S
72
119
72
119
119
70
6
ROOSEVELT
NATIONAL
FORES
INDIAN PEAKS
WILDERNESS
GOLDEN GATE CANYON
STATE PARK
Nederland
Idaho Springs
Central City
Black Hawk



Study Area
Existing South Boulder Diversion Canal
Existing Conduits 16 & 22
Existing Moffat Treatment Plant
Existing Moffat Tunnel
Stream/River

Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

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Moffat Collection System
Project FEIS

Figure 2-6
Alternative 1c
Components

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Table 2-12
Alternative 1c – Primary Components

Facility	Component Description
Gross Reservoir Expansion and Dam Raise	Additional 40,700 AF of storage capacity
	85-foot dam raise
	New concrete spillway over dam raise
	New auxiliary spillway south of dam
	Four construction staging areas
	Relocation of existing recreation and visitation facilities
	Borrow material: approximately 60% of the total borrow material produced on site; up to 40% of fine aggregate obtained from off-site commercial sources
	Relocation of existing dam and spillway access roads
	Two stockpile and two spoil areas and associated haul roads
	No modification to existing outlet works
New Leyden Gulch Reservoir	31,300 AF of new storage volume
	177-foot high new earthfill dam
	Relocation of approximately 4,000 feet of SH 93
	South Boulder Diversion Canal relocation (1-mile segment)
	All borrow material from reservoir pool area
	8-foot diameter outlet tunnel and buried pipelines connecting to Conduits 16 and 22

Notes:
% = percent
AF = acre-feet
SH = State Highway

2.4.2 Project Components

2.4.2.1 Gross Reservoir

The existing Gross Reservoir stores 41,811 AF and has a surface area of 418 acres at elevation 7,282 feet (spillway elevation). Under Alternative 1c, Gross Reservoir would be expanded to approximately 82,511 AF in order to provide an additional 40,700 AF of storage. The proposed reservoir surface area at normal water level (elevation 7,357 feet) would expand to approximately 651 acres inundating approximately 233 acres of surrounding shoreline. Currently, there is negligible seepage at Gross Dam and this is not anticipated to change under Alternative 1c. Figure 2-3 shows the extent of the enlarged Gross Reservoir. This enlargement, and associated dam construction, would require Denver Water to obtain FERC approval to amend its existing hydropower license for Gross Reservoir, Project No. 2035.

Water Source

The source of water for this alternative would be the same as that described for the Proposed Action. Average and wet-year water would be supplied from the existing Moffat Collection System in the Fraser and Williams Fork river basins and to a lesser degree from

South Boulder Creek. Existing Denver Water water rights would be used. No new water rights would be required, but it would require changing existing storage rights from Gross Reservoir to Leyden Gulch Reservoir.

Dam Features

Under Alternative 1c, Gross Dam would be raised by 85 feet. This mass concrete dam enlargement would raise the dam crest to the ultimate height of 425 feet, at elevation 7,391 feet. The crest length of the enlarged dam would be 1,640 feet and would have a width of 25 feet. The raised dam would have approximately the same dam axis, arch radius, crest width, and downstream slope as the existing dam section. The upstream and downstream slopes of the raised dam portion would be similar to the Proposed Action. Figure 2-4 shows the profile and sections of the Gross Dam. Table 2-11 under the Proposed Action provides a comparison of the proposed Gross Dam and Reservoir features with the existing facility.

Foundation Preparation and Excavation

Foundation preparation and excavation needed for this alternative would be the same as that described for the Proposed Action, except that the approximate depth of excavation and the depth of the grout curtain would be less.

Spillways

Spillways needed for this alternative would be the same as that described for the Proposed Action, except the spillway crest elevation would be lower (elevation 7,357 feet) and the crest of the auxiliary spillway would also be lower.

Tree Removal

Tree removal for Alternative 1c would be the same as for the Proposed Action, except a smaller area would need to be cleared between elevation 7,282 and 7,367 feet (10 feet above the elevation for the 40,700-AF enlargement).

Other Features

Other features of Alternative 1c that are similar to those described under the Proposed Action (see Section 2.3.2 for details) include the following:

- Inlet and Outlet Works
- Borrow/Embankment Materials
- Support Facilities/Staging Areas
- Roads and Access
- Recreational Facilities and Public Access
- Reservoir Delivery Infrastructure
- Utilities, Lighting, and Fencing
- Hydroelectric Facility

2.4.2.2 Proposed Leyden Gulch Reservoir

A new 31,300 AF reservoir would be constructed at Leyden Gulch in Jefferson County in order to complement the enlarged Gross Reservoir (Figure 2-7). The proposed reservoir would be built approximately 1 mile southwest of the intersection of SHs 72 and 93, immediately south of the Union Pacific rail line. The new reservoir would have a water surface area of approximately 332 acres at a normal water level elevation of 6,127 feet.

Water Source

The source of water for this alternative would be the same as that described for the Proposed Action. Average and wet-year water would be supplied from the existing Moffat Collection System in the Fraser River Basin, Williams Fork River Basin and to a lesser degree from South Boulder Creek. The Leyden Gulch Reservoir would be filled from water stored in Gross Reservoir, which would be released and delivered via the South Boulder Diversion Canal. No new water rights would be acquired, but it would require changing existing storage rights from Gross Reservoir to Leyden Gulch Reservoir.

Dam Features

The proposed Leyden Gulch Dam would be 177 feet high and constructed as an earthfill dam with a dam crest located at elevation 6,135 feet. The dam crest would be approximately 5,400 feet long and 40 feet wide. The up- and downstream slopes of the dam would be variable. Near the up and downstream toes of the dam, the slope would be approximately 8 horizontal to vertical (H:V), whereas near the crest, the slope would increase to approximately 2.5 H:V. Figure 2-8 shows the section view of the Leyden Gulch Dam. Denver Water would place topsoil on the downstream face of Leyden Gulch Dam and then revegetate the downstream face with a native grass seed mix. The final appearance of the dam face would be very similar to those found at Chatfield or Bear Creek dams in the southwest Denver Metropolitan area.

Foundation Preparation and Excavation

Foundation preparation would consist of over-excavation due to the weak foundation material and depth of weathering anticipated at the proposed Leyden Gulch Reservoir site. Foundation excavation would be up to 50 feet deep in the valley bottom, 30 feet deep on the left abutment slope, 60 feet deep on the eastern portion of the right abutment, and 25 feet deep on the western portion of the right abutment. The width of the excavation would be two times the embankment height. Foundation preparation outside of the central excavation would be 5 feet deep in the left abutment, 10 feet deep in the valley bottom, and an average of 5 feet deep in the right abutment.

Spillway

The Leyden Gulch Dam spillway structure and outlet works would be combined on the southwestern abutment of the dam. The spillway would discharge through a dry well into a series of tunnels and buried pipelines connecting to the existing Conduits 16 and 22. (Refer to Inlet and Outlet Works for more details.)

Inlet and Outlet Works

The inlet to the Leyden Gulch Reservoir would consist of a new concrete diversion box structure constructed in the South Boulder Diversion Canal approximately 300 feet upstream of the Siphon Number 6 inlet (Figure 2-7). The diversion structure would divert flow in the canal to Siphon Number 6. Approximately 400 feet of the existing siphon would remain in place to deliver flow into the reservoir. The remainder of the siphon would be removed or abandoned in place.

Water stored in Leyden Gulch Reservoir would discharge through a low level inlet to a dry well, and then into a 2,500-foot long, 8-foot diameter outlet tunnel sized to allow gravity outflow. The outlet tunnel would connect to a 750-foot long, buried 8-foot diameter pipeline under Leyden Gulch. The pipeline would connect to a second tunnel segment approximately 4,000 feet in length. This tunnel would connect to another 8-foot diameter pipeline (2,500-feet long), which would connect to the existing Conduits 16 and 22. Refer to Figure 2-7 for an illustration of the outlet works. The pipelines would be constructed in the following sequence:

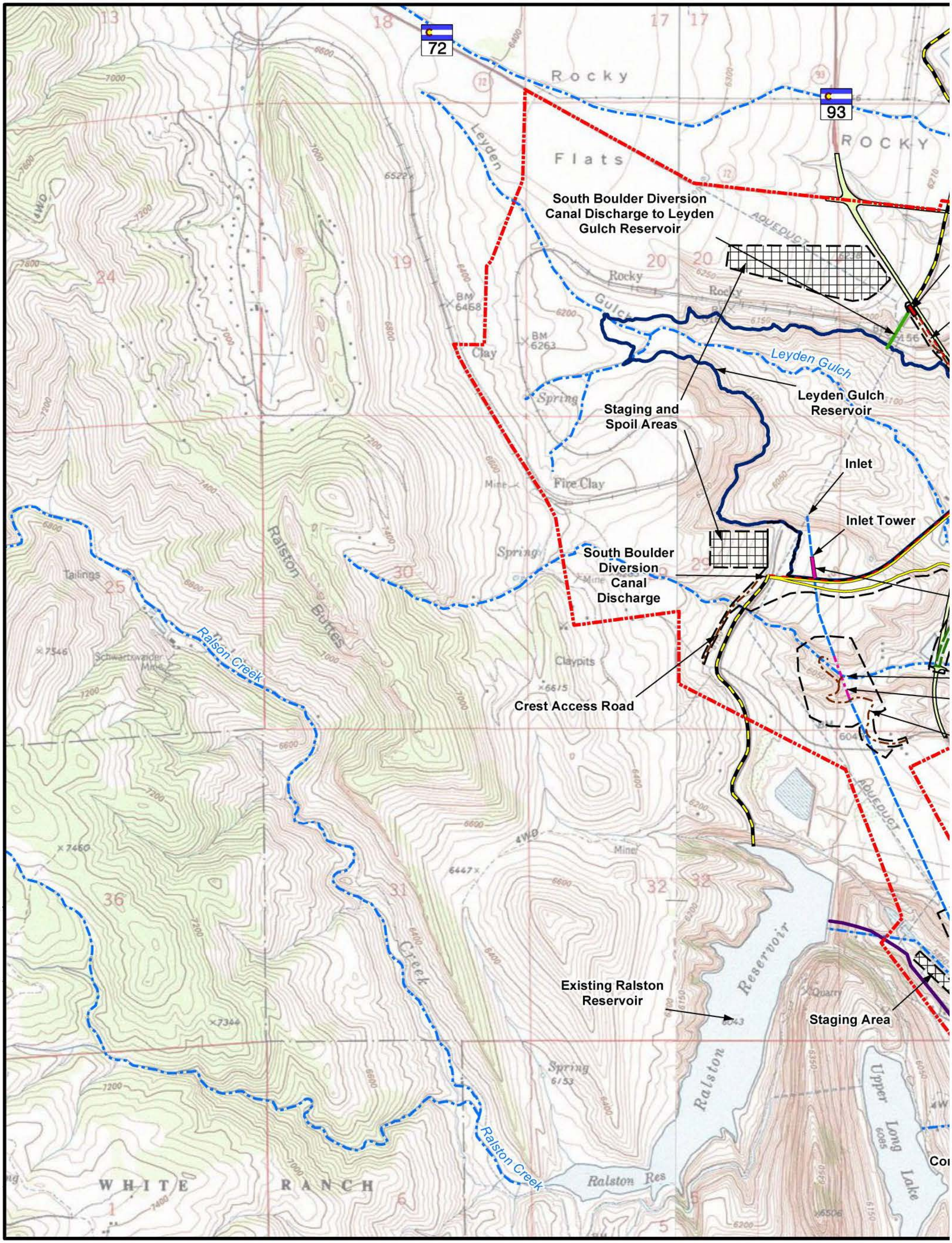
1. A trench would be excavated to a depth of about 15 feet. The trench sides would be sloped to prevent cave-ins during construction. The top width of the trench would be about 30 feet. Excavated material would be stockpiled adjacent to one side of the trench.
2. Pipe segments would be transported to and installed in the trench.
3. As pipe is installed, the trench would be backfilled with the previously excavated material. Up to about 100 feet of trench would be opened at any one time.
4. The surface would be graded to match the pre-existing grade on either side of the trench.

Tunnels would be constructed using a tunnel-boring machine that excavates material at the tunnel face and transports it, by means of a conveyor belt system, to the tunnel portal where it is than hauled away by trucks. As tunnel-boring machines advance into the tunnel, steel liner plate segments would be installed to support the tunnel. When the lined tunnel is complete, a carrier pipe would be installed in the tunnel and grouted in place.

The reason for the combination of tunnels and buried pipelines is due to elevation constraints. Tunnel construction cannot support sharp bends. Pipeline construction is anticipated under Leyden Gulch and Ralston Creek where sharp vertical bends are needed to remain underground. Three underground tunnel/pipeline connections would be constructed at the outlet of the first tunnel segment and the inlet and outlet of the second tunnel segment. An emergency outlet would be constructed at the outlet of the first (northern) tunnel to allow for draining of the reservoir, if needed.

Borrow/Embankment Materials

Borrow material for the Leyden Gulch Dam would be extracted entirely from the reservoir pool area. No off-site borrow source would be used to provide material for the Project. It is assumed that the entire reservoir basin would be cleared and grubbed prior to filling.



72
93
South Boulder Diversion Canal Discharge to Leyden Gulch Reservoir
Leyden Gulch
Leyden Gulch Reservoir
Staging and Spoil Areas
Inlet
Inlet Tower
South Boulder Diversion Canal Discharge
Crest Access Road
Existing Ralston Reservoir
Staging Area
Ralson Creek
Ralston Creek

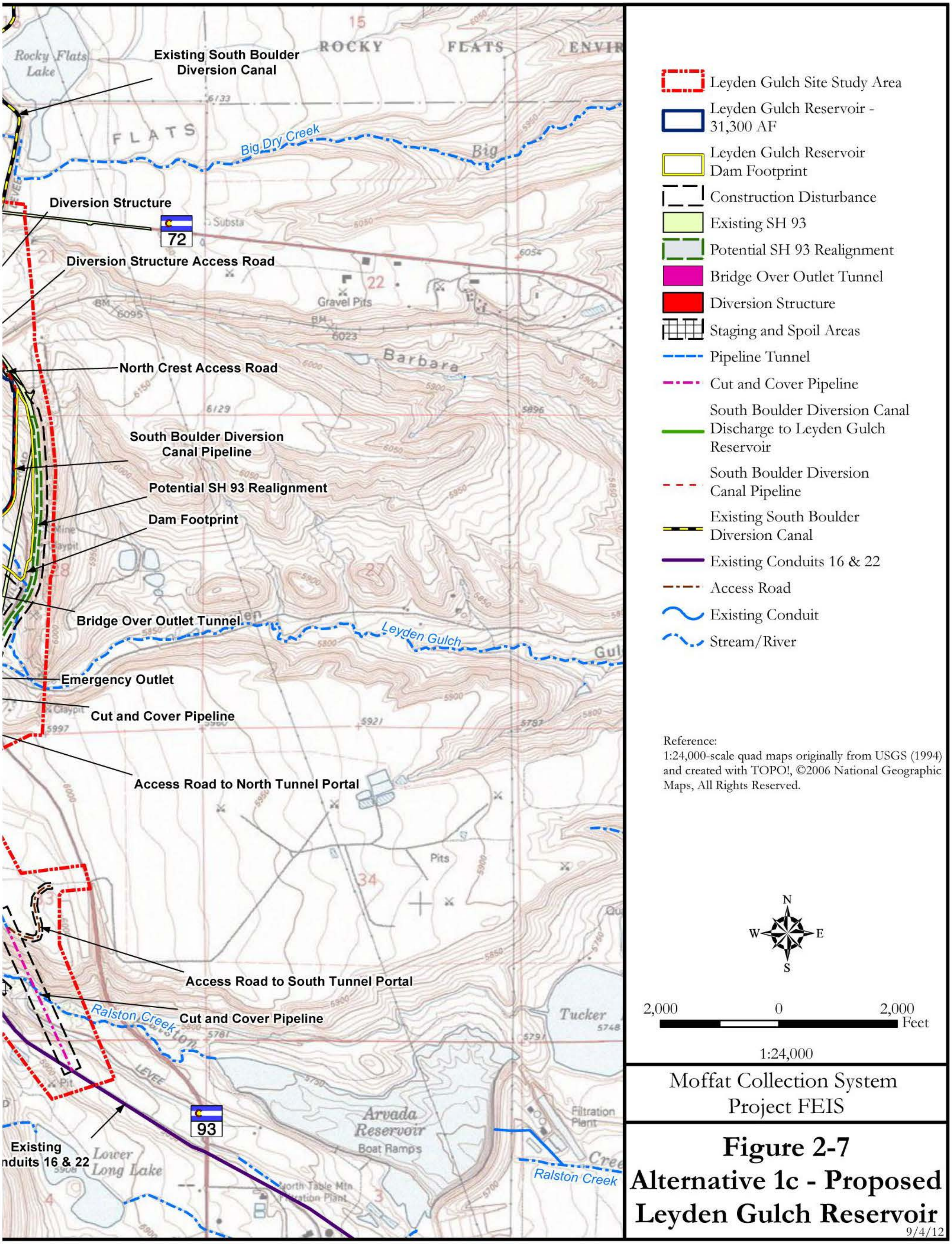


Figure 2-7
Alternative 1c - Proposed Leyden Gulch Reservoir

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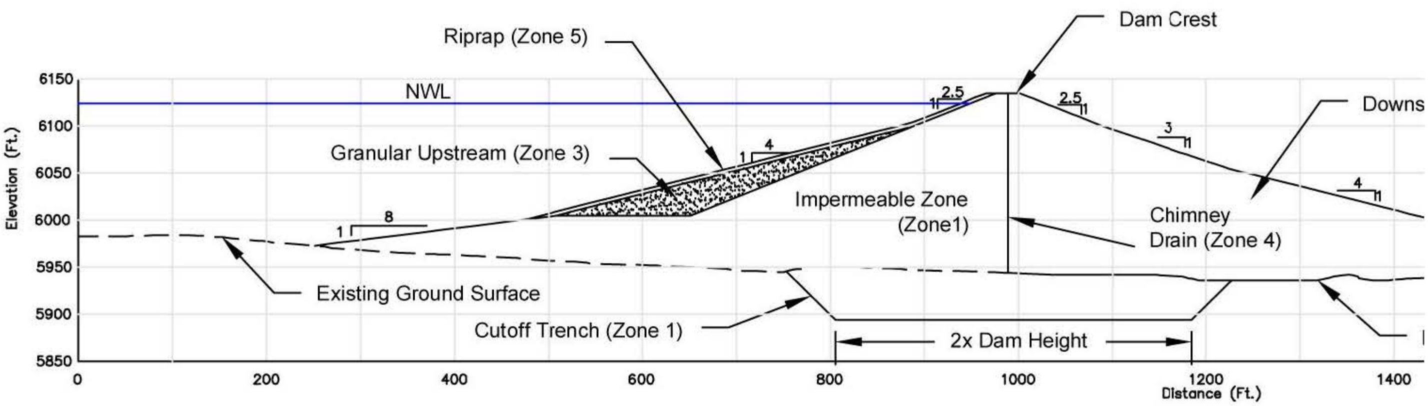
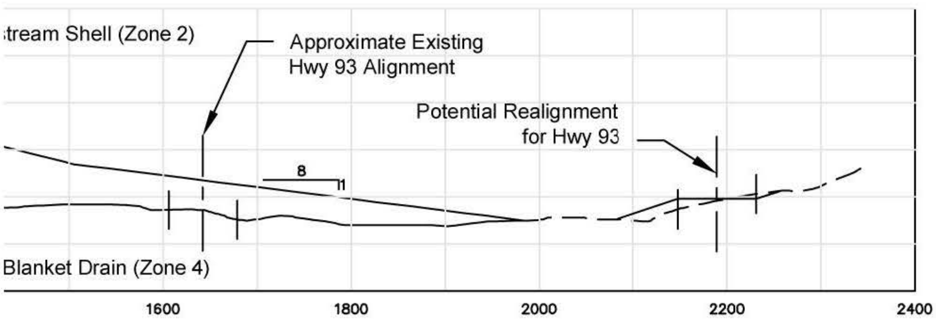


MAXIMUM EMBANKMENT SECTION 31,300 AF RES



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Note: All data provided by Denver Water (2006).

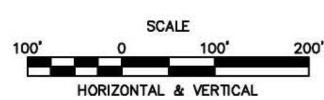

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Figure 2-8

Proposed Leyden Gulch Reservoir - Embankment Section

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Support Facilities/Staging Areas

The Leyden Gulch Reservoir would include three staging areas, one of 41 acres, one of 13.7 acres and a final one of 3.5 acres. The largest staging area, located due north of the proposed reservoir pool area, would encompass approximately 41 acres and would also serve as a spoil area. This area would store the excavated material from the reservoir pool area prior to the dam construction. Rock processing activities would not occur in the staging and spoil area; earthmoving equipment, however, would be entering and exiting this area. This area would be restored to its approximate existing condition following the completion of the reservoir. If needed for disposal of spoil material, the spoil material would be buried evenly across the area; overburden would be replaced, graded, and seeded.

The smallest staging area, located at the north end of Ralston Reservoir (east of the reservoir), would encompass 3.5 acres and would support delivery pipeline and tunnel construction activities. The remaining staging area, located at the west abutment of the dam, would encompass 13.7 acres.

Roads and Access

Access to the Leyden Gulch Dam would be available via a north crest access road adjacent to SH 93, north of the dam, and via the south crest access road, located west of the tunnel portal infrastructure.

Permanent Roadway Relocations

The proposed Leyden Gulch Dam footprint overlaps a portion of SH 93. Approximately 4,000 feet of SH 93 would be permanently relocated. The SH 93 realignment would be constructed before the dam embankment. The existing SH 93 would remain in service while the realignment is constructed. The realignment would be tied in to SH 93 and traffic would be routed onto the realignment. The existing portion of SH 93 would be removed after the completion of the realignment. The permanent road would be the same width as the existing two-lane highway. It is assumed that all material for the highway foundation would be available on site. Asphalt paving would be acquired from a commercial supplier in the area. The highway realignment would be located between the toe of the proposed dam and the hogback feature east of the dam footprint.

Five permanent access roads would be constructed at Leyden Gulch Reservoir with this alternative. These roads would also be used during construction for access. Each road would be approximately 30 feet wide with a gravel surface (approximate length in parentheses):

- Diversion Structure Access Road (725 feet)
- North Crest Access Road (755 feet)
- Crest Access Road (1,900 feet)
- Access Road to the North Tunnel Portal (3,200 feet) with a 200-foot long spur to access the emergency outlet
- Access Road to the South Tunnel Portal (1,600 feet)

Recreational Facilities and Public Access

No recreational facilities or public access would be provided at a new Leyden Gulch Reservoir.

Reservoir Delivery Infrastructure

To the Reservoir(s)

There would be no changes to the delivery of water supplies from the West Slope with this alternative. (Refer to the Proposed Action for a description of the West Slope Collection System including the Moffat Tunnel and South Boulder Creek above Gross Reservoir.)

Water discharged from Gross Reservoir and diverted to the South Boulder Diversion Canal would be delivered to raw water customers or conveyed in the existing canal to the new Leyden Gulch Reservoir. A new diversion structure in the South Boulder Diversion Canal would be required to supply water to Leyden Gulch and Ralston reservoirs.

A new concrete diversion box structure would be constructed in the South Boulder Diversion Canal approximately 300 feet upstream of the Siphon Number 6 inlet (Figure 2-7). The diversion box would contain gates to direct flow from the South Boulder Diversion Canal in either of two directions:

1. Flow would bypass Leyden Gulch Reservoir through the proposed "South Boulder Diversion Canal Pipeline," routed along the crest of the proposed Leyden Gulch Dam, to a second new concrete transition structure tying back in to the existing South Boulder Diversion Canal about 800 feet downstream of the existing Siphon Number 6 outlet. Approximately 1 mile of the existing South Boulder Diversion Canal would be relocated out of the new Leyden Gulch Reservoir pool area, around the crest of the dam.
2. Flow would enter Leyden Gulch Reservoir through the existing Siphon Number 6. Most of Siphon Number 6 would be removed or abandoned in place with one exception: the most-upstream 400 feet of the siphon would be retained as the connection between the new diversion box and the reservoir. A short section of the South Boulder Diversion Canal between Siphon Number 6 and the new South Boulder Diversion Canal pipeline outlet would be abandoned in place.

From the Reservoir

Water would be released from Leyden Gulch Reservoir through a new low-level outlet pipe to a network of tunnels and pipelines, which connect to the existing Conduits 16 and 22. (Refer to Inlet and Outlet Works above for more details.) Leyden Gulch Reservoir would be situated such that there would be sufficient head (elevation) to deliver water by gravity to a connection with Conduits 16 and 22 and back to Ralston Reservoir. Conduits 16 and 22 would also be used to deliver water by gravity to the Moffat WTP.

Ralston Reservoir could continue to be supplied with water flowing in the South Boulder Diversion Canal or with water released from the proposed Leyden Gulch Reservoir via Conduits 16 and 22.

Utilities, Lighting, and Fencing

An aboveground wood post, 12-kilovolt transmission line would be constructed from the vicinity of SH 93 to the new Leyden Gulch Dam to provide electrical power for outlet valves, telemetry equipment, and service lighting. The precise alignment of this power line has not been determined at this stage of the Project development.

Operation and maintenance roads would be gated to prevent non-authorized vehicle access and posted to prevent non-vehicular access. Steel or wood post, barbed wire stock fence would be constructed to enclose lands owned by Denver Water.

2.4.3 Proposed Changes to Denver Water's System Operations

The proposed changes to Denver Water's system operations would be the same as those described for the Proposed Action, except that Moffat Collection System supplies would also be stored in a new Leyden Gulch Reservoir. (Refer to Section 5.1 for details on the proposed hydrologic changes.) Water stored in Gross Reservoir would be released and delivered via the South Boulder Diversion Canal to Leyden Gulch Reservoir. Water would be released from Gross Reservoir for storage in Leyden Gulch Reservoir in an effort to maintain Leyden Gulch Reservoir full. This would stage water closer to the Moffat WTP and maximize the space that would be available in Gross Reservoir for collection of Moffat Collection System supplies. As a result, reservoir contents at Gross Reservoir would fluctuate more in comparison with Leyden Gulch and Ralston reservoirs.

Water would be released from Leyden Gulch and Ralston reservoirs as needed to meet demands at Moffat WTP. Releases from Leyden Gulch Reservoir would be conveyed via Conduits 16 and 22 to either Ralston Reservoir or directly to the Moffat WTP.

2.5 ALTERNATIVE 8A – GROSS RESERVOIR EXPANSION (52,000 AF)/REUSABLE RETURN FLOWS/GRAVEL PIT STORAGE (5,000 AF)

2.5.1 Introduction/Abstract

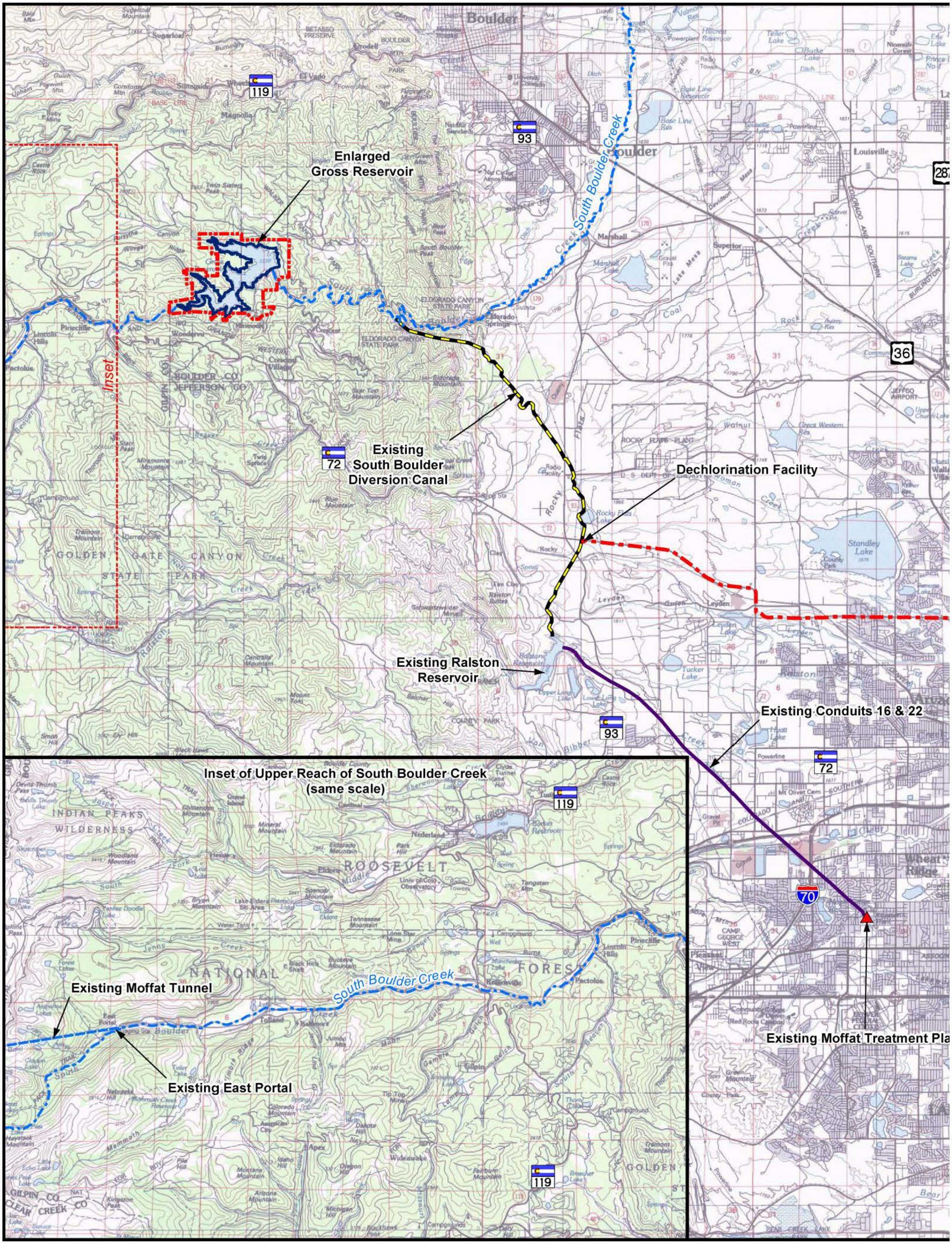
Alternative 8a would combine storage of Moffat Collection System supplies in an expansion of the existing Gross Reservoir with reusable return flows to provide 18,000 AF/yr of new firm yield. Approximately 13,000 AF/yr of new firm yield would be provided by the expansion of Gross Reservoir, while 5,000 AF/yr of new firm yield would be provided by reusable return flows stored in gravel pits along the South Platte River. Figure 2-9 displays the Alternative 8a components.

The existing Gross Dam would be raised 101 feet to provide an additional 52,000 AF of new storage capacity in an expanded Gross Reservoir. When available, additional water diverted from the Fraser River, Williams Fork River, and South Boulder Creek at existing Denver Water facilities under existing Denver Water water rights, would be stored in the expanded Gross Reservoir.

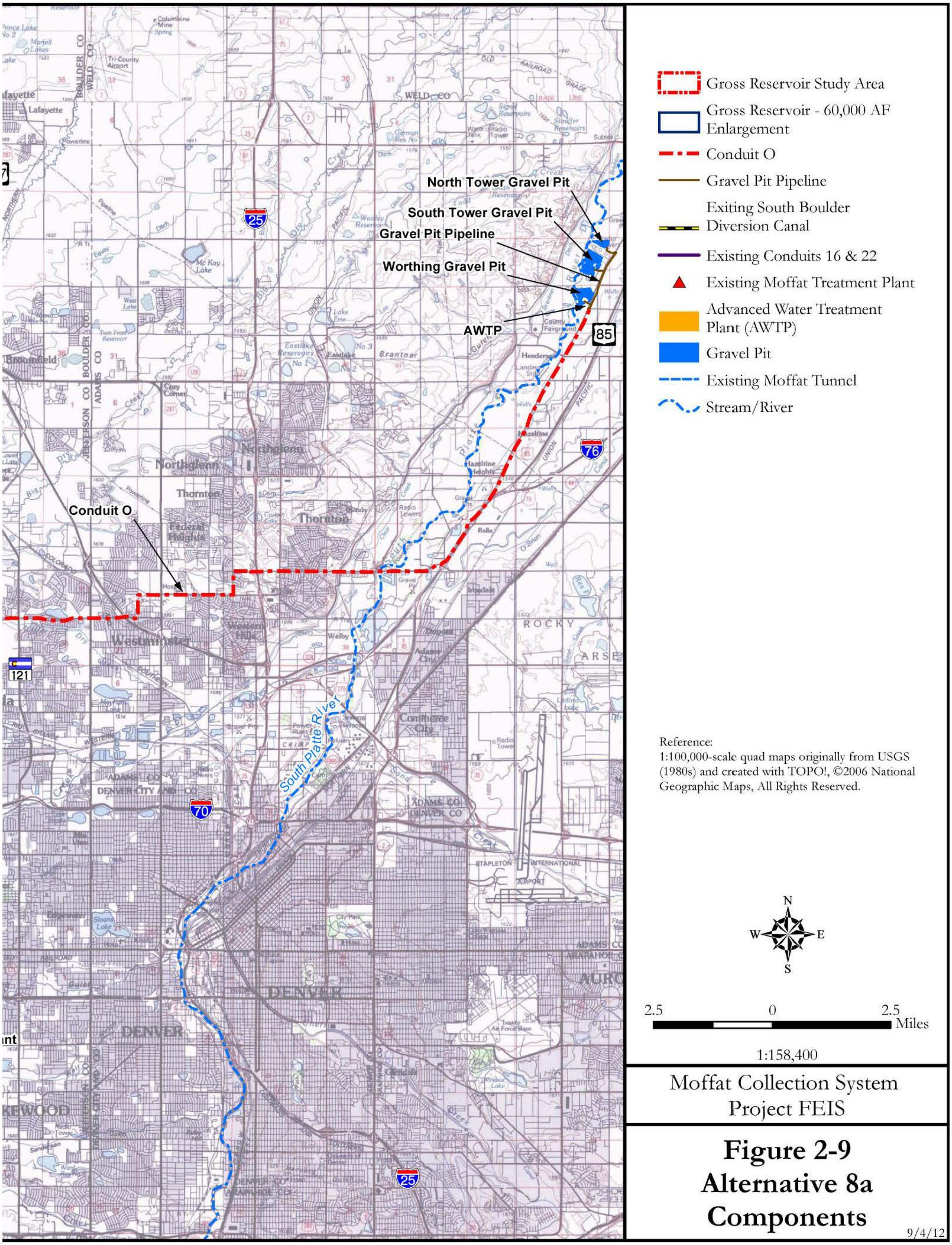
A new diversion structure and gravel pit storage facilities would be constructed along the South Platte River. Reusable return flows would be diverted from the South Platte River, when available, to fill the new gravel pit storage facilities. When needed, water would be recovered from gravel pit storage, treated at a new AWTP, and conveyed via new pipelines to the Moffat Collection System.

The gravel pit storage facilities (gravel pits, diversion structure, pipelines, and AWTP) are considered representative of typical facilities of other existing facilities along the South Platte River. The actual location and configuration of the gravel pits, the AWTP, and associated facilities would be determined during the design phase should this alternative be permitted by the Corps.

Table 2-13 lists the major components of this alternative. Details are presented in the Project Components discussion below.



Enlarged Gross Reservoir
Existing South Boulder Diversion Canal
Dechlorination Facility
Existing Ralston Reservoir
Existing Conduits 16 & 22
Existing Moffat Treatment Pla
Inset of Upper Reach of South Boulder Creek (same scale)
Existing Moffat Tunnel
Existing East Portal
South Boulder Creek
Inset



Moffat Collection System Project FEIS

Figure 2-9 Alternative 8a Components

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Table 2-13
Alternative 8a – Primary Components

Facility	Component Description
Gross Reservoir Expansion and Dam Raise	Additional 52,000 AF of storage capacity
	101-foot dam raise
	New concrete spillway over dam raise
	New auxiliary spillway south of dam
	Four construction staging areas
	Relocation of existing recreation and visitation facilities
	Borrow material: approximately 60% of the total borrow material produced on site; up to 40% of fine aggregate obtained from off-site commercial sources
	Relocation of existing dam and spillway access roads
	Two stockpile and two spoil areas and associated haul roads
	No modification to existing outlet works
South Platte River Diversion	150-foot long concrete diversion in the South Platte River – representative design
	750-feet, 54-inch pipeline from diversion to gravel pit storage
Gravel Pit Storage	Worthing, North Tower, and South Tower pits – representative sites
	Practical storage volume of approximately 5,000 AF (total of all pits)
	Perimeter slurry wall to prevent groundwater seepage
	1.4 miles of 36-inch pipeline and pump stations connecting three gravel pits
Advanced Water Treatment Plant	Located near Worthing Pit – representative site
	Process train: sedimentation, low-pressure membrane pretreatment, reverse osmosis, advanced oxidation, disinfection, and zero-liquid discharge
	13.6 mgd capacity
	4-acre plant site and 70-acre evaporating pond/drying beds
Dechlorination Facility	0.1 acre site – representative site
Pipeline (Conduit O)	25 miles long, 36-in diameter pipeline connecting the new Advanced Water Treatment Plant and the Moffat Collection System – representative alignment
	Three 2,000-horsepower pump stations

Notes:
% = percent
AF = acre-feet
mgd = million gallons per day

2.5.2 Project Components

2.5.2.1 Gross Reservoir

The existing Gross Reservoir stores 41,811 AF and has a surface area of 418 acres at elevation 7,282 feet (spillway elevation). Under Alternative 8a, Gross Reservoir would be expanded to approximately 93,811 AF in order to provide an additional 52,000 AF of storage. The proposed reservoir surface area at normal water level would expand to approximately 712 acres inundating approximately 294 acres of surrounding shoreline at elevation 7,374 feet. The enlargement, and associated dam construction, would require Denver Water to obtain FERC approval to amend its existing hydropower license for Gross Reservoir, Project No. 2035.

Water Source

The water source would be the same as the Proposed Action. Average and wet-year water would be supplied from the existing Moffat Collection System in the Fraser and Williams Fork river basins, and South Boulder Creek. Existing Denver Water water rights would be used. No new water rights would be required.

Dam Features

Under Alternative 8a, the Gross Dam would be raised by 101 feet. This mass concrete dam enlargement would raise the dam crest to a height of 441 feet, at elevation 7,374 feet. The crest length of the enlarged dam would be 1,708 feet and would have a width of 25 feet. The raised dam would have approximately the same dam axis, arch radius, crest width, and downstream slope as the existing dam section. The upstream and downstream slopes of the raised dam portion would be similar to the Proposed Action. Figure 2-4 shows the profile and sections of the Gross Dam. Table 2-11 provides a comparison of the proposed Gross Dam and Reservoir features with the existing facility.

Foundation Preparation and Excavation
Foundation preparation and excavation would be the same as the Proposed Action, except that the approximate depth of excavation and the depth of the grout curtain would be less.

Spillways
The spillways would be the same as the Proposed Action, except that the crest elevations of the spillway (elevation 7,374 feet) and auxiliary spillway would be lower.

Tree Removal
Tree removal for Alternative 8a would be the same as for the Proposed Action, except a smaller area would need to be cleared between elevation 7,282 and 7,384 feet (10 feet above the elevation for the 52,000-AF enlargement).

Other Components

Other components of Alternative 8a that are similar to those described under the Proposed Action include the following (refer to the Proposed Action, Section 2.3.2 for details):

- Inlet and Outlet Works
- Borrow/Embankment Materials
- Support Facilities/Staging Areas
- Roads and Access
- Recreational Facilities and Public Access
- Reservoir Delivery Infrastructure
- Utilities, Lighting, and Fencing
- Hydroelectric Facility

2.5.2.2 Proposed Gravel Pit Storage Facilities

Reusable return flows would be diverted from the South Platte River and stored in gravel pit reservoirs. The gravel pits provide both regulating and firming storage prior to delivery to the Moffat Collection System. Modeling of this alternative with PACSM indicates that approximately 5,000 AF of storage would be required to create the firm yield contemplated for the reusable effluent portion of this alternative. Given the typical size of gravel pits along this reach of the South Platte, several gravel pit storage sites would be required to develop this volume. For purposes of this EIS analysis, three existing gravel pits, the Worthing, South Tower, and North Tower pits, were identified as representative pits that could be converted into gravel pit storage facilities for this alternative (Figure 2-10). The combined storage volume is assumed to be approximately 5,000 AF (Boyle 2006c).

For the purposes of this EIS analysis, these gravel pits were considered representative of gravel pit storage along the South Platte River, since they appear typical of gravel pits in the area in size, form, function, and location. The final combination of gravel pits would be determined during the design phase should this alternative be permitted. The gravel pit storage sites would be connected hydraulically using a system of minor pump stations and pipelines and described below in further detail.

State regulations require an impermeable barrier to prevent infiltration of groundwater into the reservoir. This barrier would be provided by slurry walls. Slurry walls are narrow trenches backfilled with a low permeability material to form a barrier to groundwater movement. The slurry consists of a mixture of powdered bentonite and water. In addition, the side slopes of the mined pit are backfilled with soil to create a stable slope. Refer to Figure 2-11 for a schematic drawing of a typical gravel pit storage facility. It is common practice for the aggregate operator to complete the required barrier as part of its operating or reclamation plan. For purposes of this EIS analysis, it is assumed that when Denver Water acquires the gravel pits they would be completely mined and reclaimed for use as an empty water storage facility.

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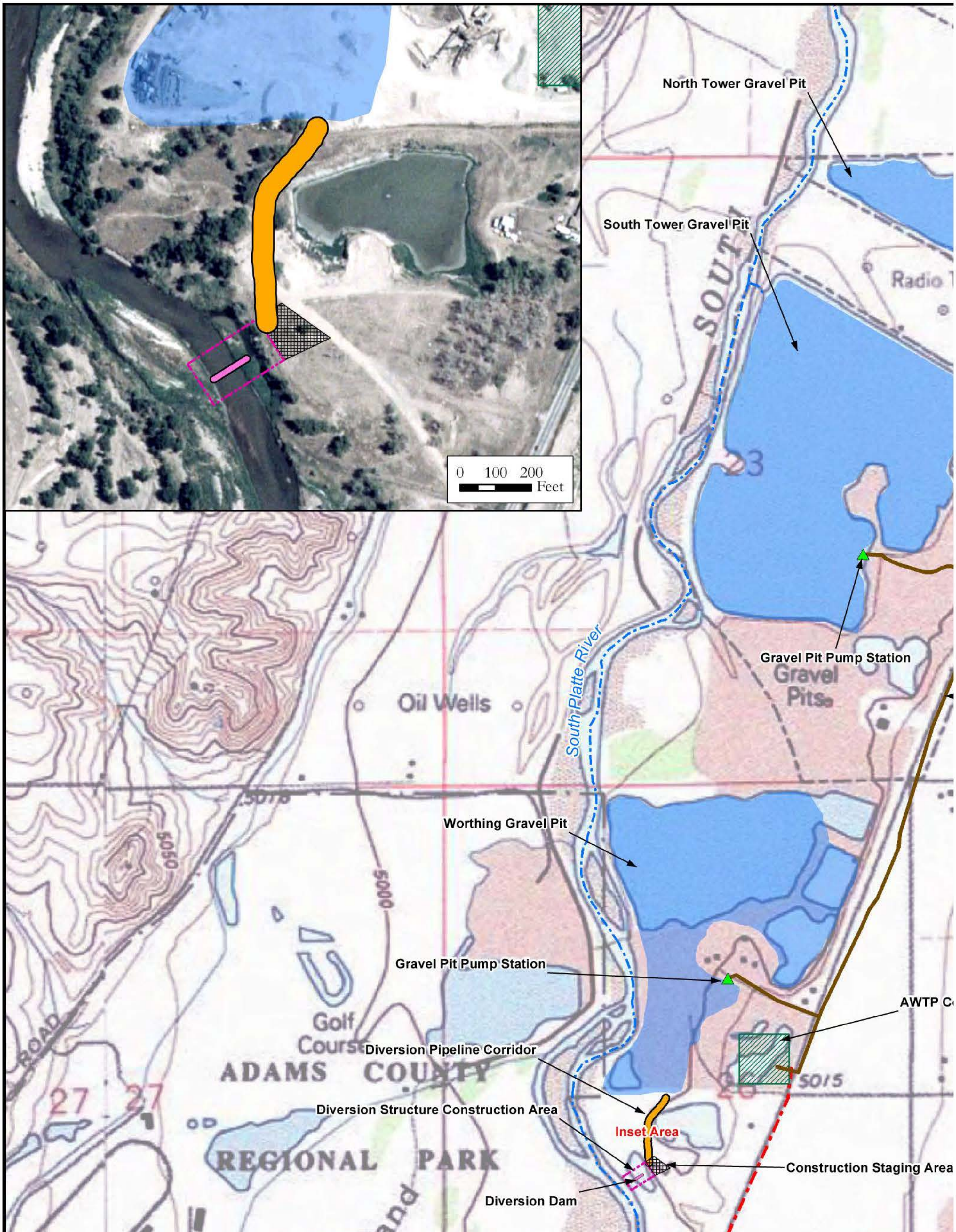

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Feet
North Tower Gravel Pit
South Tower Gravel Pit
Radio T
Gravel Pit Pump Station
Gravel Pits
Oil Wells
South Platte River
Worthing Gravel Pit
Gravel Pit Pump Station
AWTP C
Golf Course
Diversion Pipeline Corridor
ADAMS COUNTY
Diversion Structure Construction Area
Inset Area
REGIONAL PARK
Construction Staging Area
Diversion Dam
5015
5000
5050

- Conduit O
- Gravel Pit Pipeline
- Gravel Pit Pump Station
- Diversion Dam
- Diversion Pipeline Corridor
- Construction Staging Area
- Diversion Structure Construction Area
- Advanced Water Treatment Plant (AWTP) Construction Area
- Gravel Pit
- Stream/River

References:
1:24,000-scale quad maps originally from USGS (1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Aerial photography from USDA (2005).

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Figure 2-10
Alternative 8a
Typical Gravel Pit Storage Facilities

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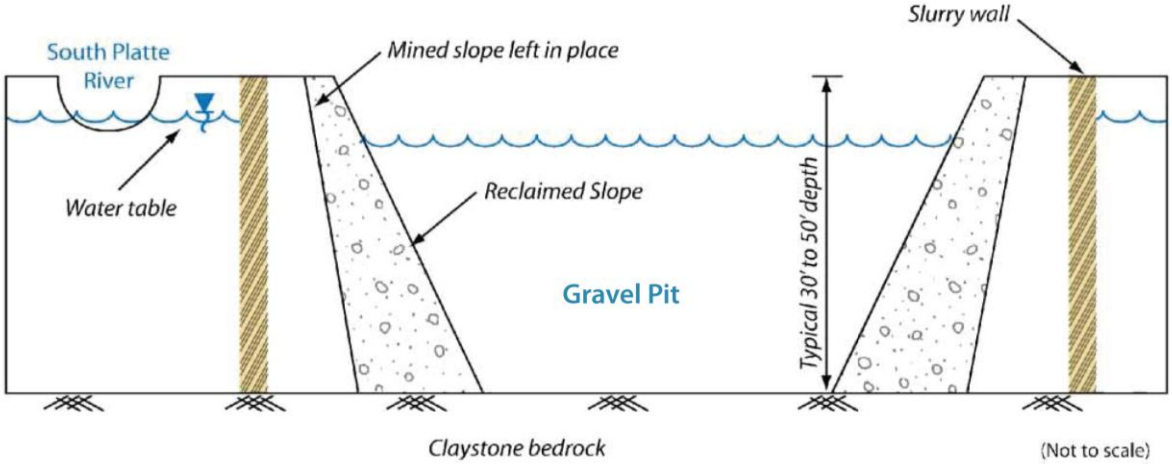
Figure 2-11
Typical Slurry Wall Lined Gravel Pit



Source: MWH, 2006.

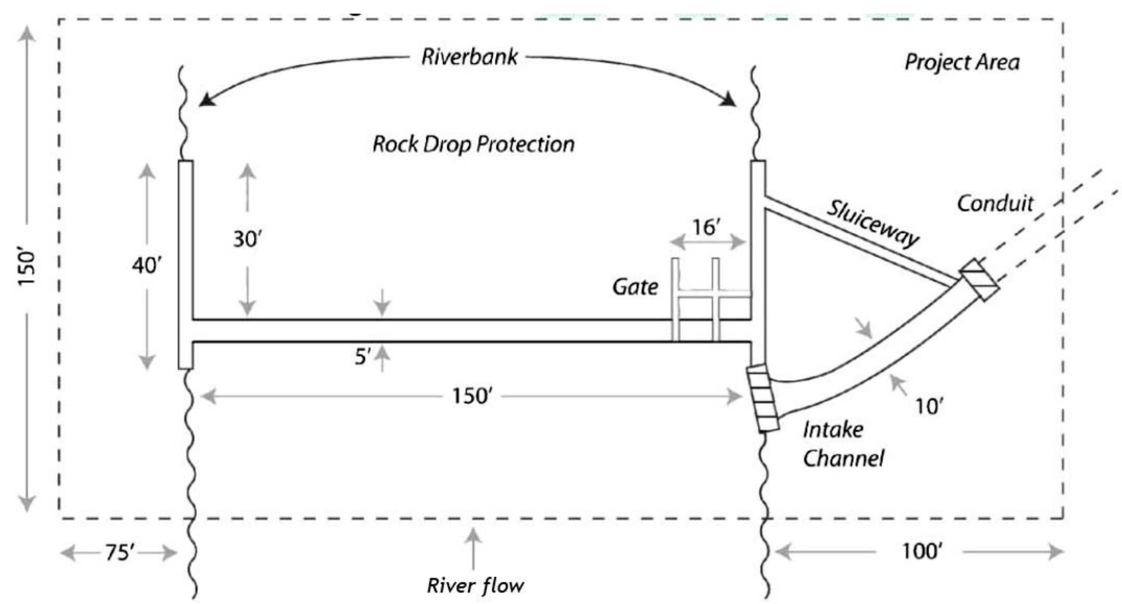
Water Source

Reusable return flows would be diverted from the South Platte River, when available, to fill the new gravel pit storage facilities. Reusable return flow includes water imported from the Blue River and the Meadow-Cabin Creek Basin in the Fraser River Basin, and fully consumable agricultural water. They include water applied to indoor use and delivered to the river via the WWTPs, and LIRFs. The amount of water from each of these sources varies from year to year depending on Denver Water's operations, which are responsive to hydrologic conditions. The amount of available reusable effluent depends not only on the amount of reusable source water consumed, but also on use of reusable return flow credits to run exchanges. PACSM showed that the amount of reusable return flow available each year could range from zero to 37,555 AF (refer to Table 2-9). The amount of unused reusable supplies available would vary considerably from year to year. In Alternative 8a, approximately 5,000 AF/yr of new firm yield would be provided by reusable return flows stored in gravel pits along the South Platte River. For the purposes of this EIS analysis, the amount of reusable supplies included in Alternative 8a was based on a review of the amount of reusable water available, available gravel pit storage along the South Platte River, and potential water quality issues associated with blending reusable supplies with Moffat Collection System supplies. The final configuration of this alternative would be determined during the design phase should this alternative be permitted.

Diversion Structure

To capture the reusable return flow, a new diversion would be constructed in the South Platte River near the Worthing Pit storage facility. Figure 2-12 shows a typical design for a river diversion. The diversion would extend across the active South Platte River channel (low flow channel plus first terrace). The diversion and associated construction disturbance area are shown schematically in Figure 2-12.

Figure 2-12
Typical River Diversion Structure



Source: MWH, 2006.

The diversion headgate would discharge to a 750-feet long buried 54-inch pipeline connected to the southern gravel pit storage area. The pipeline would follow an existing gravel road. The potential temporary construction disturbance area for the conduit would include the existing gravel road, plus a 40-foot wide area immediately west of the road. Construction access for the new diversion structure and conduit would occur from existing paved and unpaved roads in the area.

Gravel Pit Pipeline

In order to provide sufficient storage, the gravel pit storage facilities would be connected hydraulically via a 36-inch buried, bi-directional pipeline and associated pump stations. Approximately 1.4 miles of pipeline would be installed to the east of the gravel pits along existing roadways from the Worthing Pit north to the North Tower Pit (Figure 2-10). The pipeline would be constructed in the existing roadways (curb-to-curb). Bi-directional, lateral pipelines would be installed connecting each gravel pit to the 36-inch pipeline. The lateral pipelines would be constructed in existing access roads. To fill the gravel pits, water would be diverted from the South Platte River and discharged to each gravel pit’s lake from the lateral pipelines, based on the storage capacities. When needed, water stored in the gravel pits would be pumped and delivered via the 36-inch bi-directional pipeline to the new AWTP. Three pump stations (one at each gravel pit storage facility), with a capacity of 2,000-horsepower each, would be required to deliver water from the gravel pits to the new AWTP. Each pump station would be located adjacent to the gravel pit and would consist of a concrete box structure with three vertical turbine pumps installed inside the pumphouse.

Advanced Water Treatment Plant

Water withdrawn from gravel pit storage would be treated at the new AWTP, then conveyed via Conduit O to the South Boulder Diversion Canal to Ralston Reservoir, and then to the existing Moffat WTP. When water originating in the Fraser River, Williams Fork River, and South Boulder Creek basins is also being delivered to the Moffat WTP, the two water sources would mix in the canal prior to discharge into Ralston Reservoir. South Platte River return flow water quality is substantially different and of lesser quality than existing Moffat Collection System supplies. Since the existing Moffat WTP would be incapable of treating the resulting blended supply to meet drinking water standards, a new 13.6 mgd AWTP would be required to treat the South Platte River return flows prior to their introduction to the Moffat Collection System. The treatment process would involve sedimentation, low-pressure membrane pre-treatment, reverse osmosis, advanced oxidation, disinfection, and ZLD for the residual disposal.

For purposes of analysis in the EIS, it is assumed that the new AWTP would occupy approximately 4 acres adjacent to the Worthing Pit (Figure 2-10) and would consist of several buildings and structures no more than two stories in height (about 25 to 30 feet). Building architecture would be designed to be consistent with the surrounding area. Low wattage light fixtures would be included to provide security lighting, and structures would be equipped with sound mitigation features to comply with applicable local noise ordinances. The AWTP site would be fenced to limit access to authorized personnel. A buried pipeline would deliver the waste stream or brine from the AWTP to the disposal site. The 13.6 mgd plant would require approximately 70 acres of evaporation pond and drying beds, located near the plant.

If Alternative 8a is chosen, Denver Water would locate the disposal facility on an upland site in a commercial, industrial, or other area compatible with surrounding land uses, in close proximity to the AWTP. The location would be evaluated to avoid or minimize interferences with sensitive environmental areas, including wetlands, threatened and endangered species habitat, and cultural resources. Denver Water would conduct the appropriate level of analyses and obtain all necessary permits prior to constructing and operating the AWTP.

The AWTP would operate only as needed. Based on the hydrologic modeling for Alternative 8a (refer to Section 5.1), the AWTP would operate for approximately 2 to 3 years and then either shut down or be placed in a low flow (idle) status for 6 to 7 years.

Conduit O

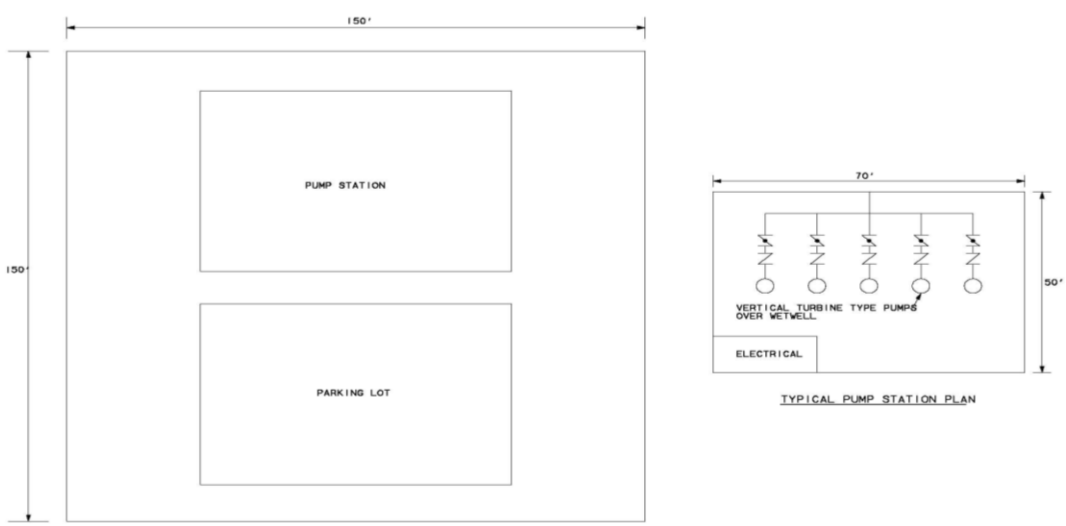
A new pipeline would be required to deliver water from the new AWTP to Moffat Collection System. A 36-inch diameter, 25-mile pipeline (Conduit O) would be constructed from the new AWTP to the Moffat Collection System. Figure 2-9 shows a representative alignment for purposes of this EIS. The pipeline would cross railroad tracks, highways, and several roads using Denver Water's standard bore and jack method. Crossing the South Platte River and other drainages would be open cut per Denver Water's standard method. Refer to Section 2.8.3 for details. It is assumed that the conduit would be constructed within existing roadways (curb-to-curb). The exact alignment would be selected to minimize interferences with environmentally sensitive areas, railroads, highways, watercourses, and property boundaries.

Design features associated with Conduit O, such as locations of flow control valves, PRVs, blow-offs, air release/air vacuum valves and thrust restraints, would be located within the identified pipeline corridor and would result in no additional temporary construction disturbance and minimal or no permanent surface disturbance.

Conduit O would terminate at the Moffat Collection System delivery point, which is at the South Boulder Diversion Canal. A small concrete box would be constructed in the bank of the canal to support the pipeline.

Three pump stations, with a capacity of 2,000-horsepower each, would be required to deliver water along Conduit O. Pumps would be driven by electric motors. One pump station would be located at the AWTP site near the Worthing Pit, and two pump stations would be located along the pipeline route to the Moffat Collection System. The pump stations would be located within the pipeline corridor. The maximum construction disturbance areas would be approximately 200 feet by 200 feet for each pump station. Permanent fenced areas for each pump station would be a maximum of approximately 150 feet by 150 feet. A typical pump station layout is shown in Figure 2-13. Each pump station would be enclosed in a building approximately 70 feet by 50 feet and would be no more than two stories in height (about 25 to 30 feet). Building architecture would be designed to be consistent with the surrounding area. Low wattage light fixtures would be included to provide security lighting. Pump stations would be equipped with sound mitigation features to comply with applicable local noise ordinances. Each pump station site would be fenced to limit access to authorized personnel.

Figure 2-13
Typical Pump Station Layout



Source: MWH, 2006.

Dechlorination Facility

A small dechlorination facility would be required at a location near the Moffat Collection System delivery point. This would be a 2,000 square-foot structure located on less than 1 acre. The proposed facility would be fenced, but would not have exterior lighting. The dechlorination facility would inject liquid sodium bisulfite into the pipeline, neutralizing the chlorine residual. Figure 2-14 represents a typical dechlorination facility.

Figure 2-14
Denver Water Dechlorination Facility

Source: URS, 2007.

Roads and Access

Brighton Road would provide access to the gravel pit storage sites, new diversion structure, and AWTP. Construction access for the new diversion structure and intake channel conduit on the South Platte River would occur from existing paved and unpaved roads in the area.

Recreational Facilities and Public Access

There would be no public access or recreational use of the gravel pit lakes.

Support Facilities/Staging Areas

Temporary pipeline construction staging areas for stockpiling materials and equipment, worker parking, and field office trailers would be established at several locations along the pipeline route on existing vacant lots.

Utilities, Lighting, and Fencing

Additional power facilities such as transmission lines and substations would be required to support the pump stations for Conduit O and various pipelines, gravel pit storage facilities, AWTP, etc. Power would be brought to the facilities using buried cables.

Both the AWTP and the pump stations would be equipped with low wattage lighting and perimeter fencing for security.

2.5.3 Proposed Changes to Denver Water's System Operations

The primary changes in Denver Water's North and South system operations are described under the Proposed Action (Section 2.3.3), with the following exceptions pertinent to Alternative 8a. Refer to Section 5.1 for details on the proposed hydrologic changes.

Proposed Gravel Pit Storage

Water stored in the gravel pits would generally be used for supply in dry years. Based on runoff forecasts and other Denver Water reservoir contents, Denver Water would decide in the spring whether or not to draw water from the gravel pits for delivery to the Moffat Collection System. If needed, the water would be delivered to the Moffat System as limited by treatment and conveyance capacity. Diversions would be made from the river to the gravel pits to the extent that reusable effluent is available and storage space exists in the gravel pits. In years when the stored water is not used, water would be diverted into the pits only to replace evaporative losses. The AWTP would operate only when deliveries are being made to the South Boulder Diversion Canal.

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2.6 ALTERNATIVE 10A – GROSS RESERVOIR EXPANSION (52,000 AF)/REUSABLE RETURN FLOWS/DENVER BASIN AQUIFER STORAGE (20,000 AF)

2.6.1 Introduction/Abstract

Alternative 10a would combine storage of Moffat Collection System supplies in an expansion of the existing Gross Reservoir with deep aquifer storage of reusable return flows to provide 18,000 AF/yr of new firm yield. Approximately 13,000 AF/yr of new firm yield would be provided by the enlargement of Gross Reservoir, while 5,000 AF/yr of new firm yield would be provided by reusable return flows and deep aquifer storage and recovery (ASR).

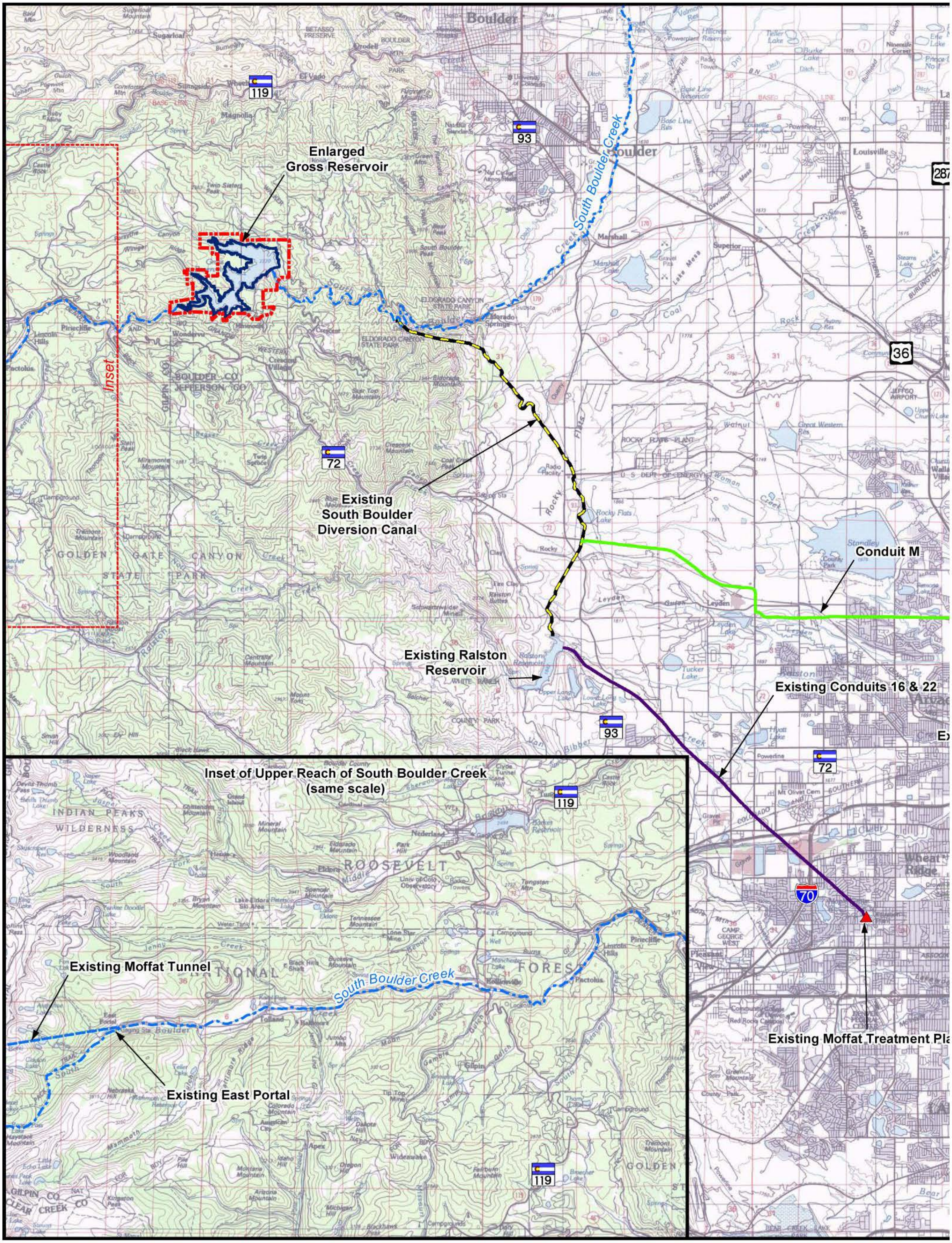
The existing Gross Dam would be raised 101 feet to provide an additional 52,000 AF of new storage capacity. When available, additional water diverted from the Fraser River, Williams Fork River, and South Boulder Creek at existing Denver Water facilities under existing Denver Water water rights, would be stored in an enlarged Gross Reservoir.

When available, reusable return flows at the Denver Water Recycling Plant would be treated at a new AWTP and conveyed via a new pipeline distribution system to an injection/recovery well field in the City of Denver. This water would be injected into the Denver Basin deep aquifers for storage. When needed, previously stored water would be recovered from the groundwater basin and conveyed through new pipelines to the Moffat Collection System.

The locations of the new AWTP, well sites, and distribution pipeline system are considered representative to illustrate how this alternative would be configured for purposes of this EIS analysis. The exact location of these components would be determined during the design phase should this alternative be permitted.

Denver Water currently uses the bulk of their reusable supplies during the summer months primarily to meet non-potable demands and as an exchange supply. As with Alternative 8a, reusable return flows for this Project would be available primarily during the winter months from November through March when Denver Water's non-potable demands and exchange potential are lowest.

Figure 2-15 displays the Alternative 10a components. Table 2-14 lists the major components of the Gross Dam and Reservoir enlargement and deep aquifer storage recovery. Details are presented in the Project Components discussion below.


Enlarged
Gross Reservoir
Existing
South Boulder
Diversion Canal
Conduit M
Existing Ralston
Reservoir
Existing Conduits 16 & 22
Existing Moffat Treatment Pla
Inset
Inset of Upper Reach of South Boulder Creek
(same scale)
Existing Moffat Tunnel
Existing East Portal
South Boulder Creek
Boulder
Louisville
Marshall
Superior
Eldorado Springs
Nederland
Rollinsville
Tolland
ROOSEVELT
GOLDEN GATE CANYON STATE PARK
INDIAN PEAKS
WILDERNESS
BOULDER CO
JEFFERSON CO
GILPIN CO
CLEAR CREEK CO
ROCKY FLATS PLANT
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287
36
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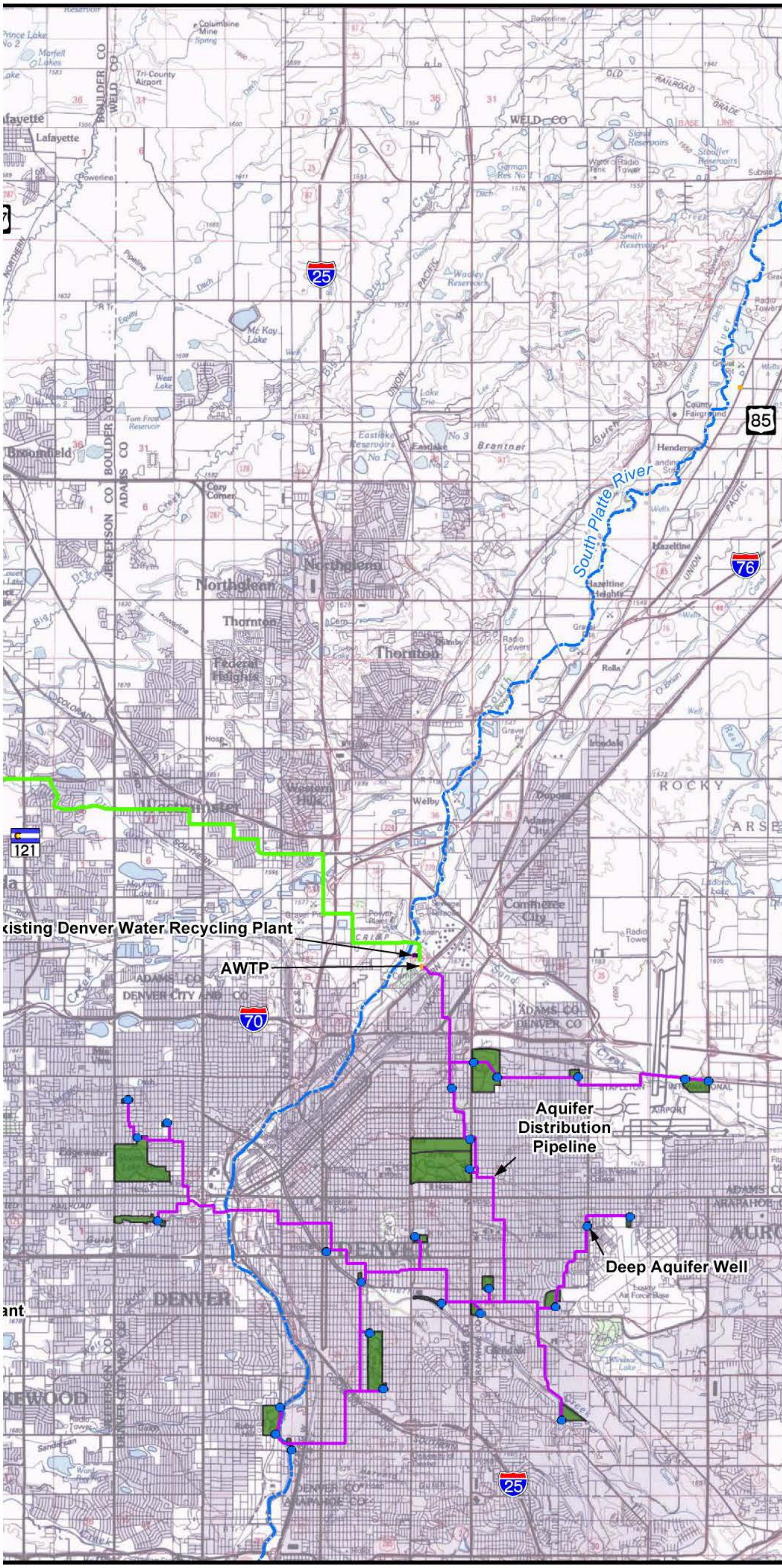

Gross Reservoir Study Area
Gross Reservoir - 52,000 AF Enlargement
Conduit M
Existing South Boulder Diversion Canal
Existing Conduits 16 & 22
Aquifer Distribution Pipeline
Existing Moffat Treatment Plant
Existing Denver Water Recycling Plant
Advanced Water Treatment Plant (AWTP)
Denver County Parks
Deep Aquifer Well
Existing Moffat Tunnel
Stream/River

Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

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Moffat Collection System
Project FEIS

Figure 2-15
Alternative 10a
Components

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Table 2-14
Alternative 10a – Primary Components

Facility	Component Description
Gross Reservoir Expansion and Dam Raise (same as Alternative 8A)	Additional 52,000 AF of storage capacity
	101-foot dam raise
	New concrete spillway over dam raise
	New auxiliary spillway south of dam
	Four construction staging areas
	Relocation of existing recreation and visitation facilities
	Borrow material: approximately 60% of the total borrow material produced on site; up to 40% of fine aggregate obtained from off-site commercial sources
	Relocation of existing dam and spillway access roads
	Two stockpile and two spoil areas and associated haul roads
	No modification to existing outlet works
Advanced Water Treatment Plant	Located near the Denver Water Recycling Plant – representative site
	Process train; sedimentation, low-pressure membrane pre-treatment, reverse osmosis, advanced oxidation, disinfection, and zero-liquid discharge
	13.6 mgd capacity
	4-acre plant site and 70-acre evaporating pond/drying beds
Denver Basin Aquifer Storage and Recovery (ASR) System	Approximately 27 injection/recovery well sites (three-well cluster at each site) – representative sites
	Storage volume of approximately 5,000 AF
	36 miles of 12- to 48-inch diameter distribution pipelines – representative alignment
Pipeline (Conduit M)	18 miles long, 36-inch diameter pipeline connecting the new Advanced Water Treatment Plant and the Moffat Collection System – representative alignment
	Three 2,000-horsepower pump stations

Notes:
% = percent
AF = acre-feet
mgd = million gallons per day

2.6.2 Project Components

2.6.2.1 Gross Reservoir

The existing Gross Reservoir stores 41,811 AF and has a surface area of 418 acres at elevation 7,282 feet (spillway elevation). Under Alternative 10a, Gross Reservoir would be expanded to approximately 93,811 AF in order to provide an additional 52,000 AF of storage.

Refer to Section 2.5.2.1, Alternative 8a, for a discussion of a 52,000 AF enlargement of Gross Reservoir. Table 2-11 provides a comparison of the proposed Gross Dam and Reservoir features with the existing facility. This enlargement, and associated dam construction, would require Denver Water to obtain FERC approval to amend its existing hydropower license amendment for Gross Reservoir, Project No. 2035.

2.6.2.2 Proposed Aquifer Storage and Recovery System

Water Source

When available, reusable return flows would be collected at the Denver Water Recycling Plant, treated at a new AWTP and conveyed via a new pipeline distribution system to an injection/recovery well field in the City of Denver. The water would be injected into the Denver Basin deep aquifers for storage. When needed, previously stored water would be recovered from the groundwater basin and conveyed through new pipelines to the Moffat Collection System. For purposes of this EIS analysis, Denver Water developed a representative layout of the potential well field, pipeline system, and AWTP, as shown in Figure 2-15. Approximately 5,000 AF/yr of new firm yield would be provided by reusable return flows. For the purposes of this EIS analysis, the amount of reusable supplies included in Alternative 10a was based on a review of the amount of reusable water available, treatment and conveyance costs associated with the reusable supplies, and potential water quality issues associated with blending reusable supplies with Moffat Collection System supplies. The final configuration of this alternative would be determined during the design phase should this alternative be permitted.

Advanced Water Treatment Plant

Under Alternative 10a, water would be injected into the Denver Basin aquifer. Because the Denver Basin aquifers are a source of public water supply, water added to the basin must be treated to at least minimum drinking water standards. Reusable return flows from the Denver Water Recycling Plant would be treated at a new 13.6 mgd AWTP to meet or exceed drinking water standards prior to injection into the aquifer, and would be the same as described for Alternative 8a. In general, the treatment process would involve sedimentation, low-pressure membrane pre-treatment, reverse osmosis, advanced oxidation, disinfection, and ZLD for the residual disposal.

For purposes of this EIS evaluation, it is assumed that approximately 4 acres in the vicinity of the existing Denver Water Recycling Plant would be required in order to construct the new AWTP. General features of the AWTP and associated off-site disposal facility would be the same as described for Alternative 8a, in Section 2.5.2.2.

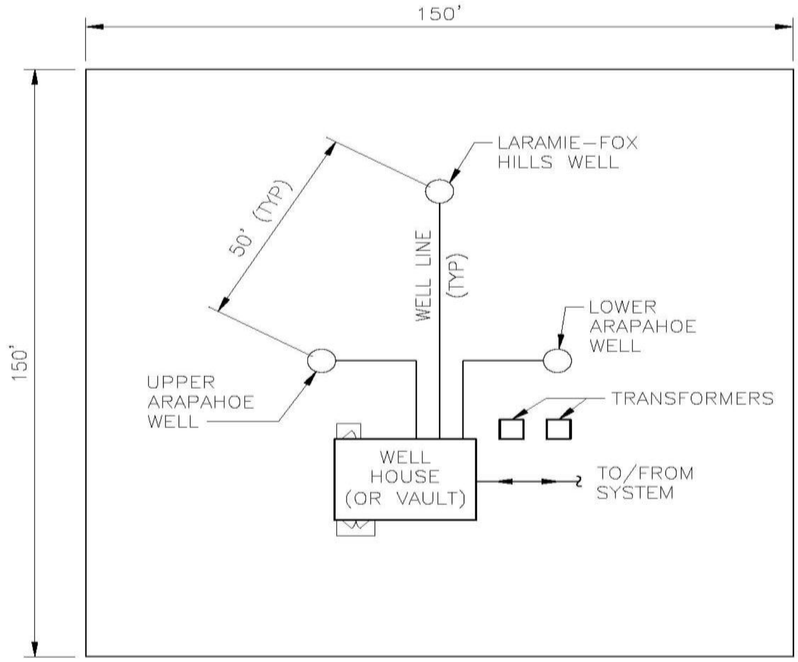
Well Sites

Water from the new AWTP would be conveyed to the injection/recovery well field, injected into the upper Arapahoe, lower Arapahoe, and Laramie-Fox Hills aquifers of the Denver Basin, and recovered as needed. At each well site, one well would be drilled into each aquifer creating a three-well cluster at each site. Individual wells in a cluster would be separated by about 50 feet to accommodate drilling and construction activities. A total of 27 well facilities (81 individual wells) would be necessary for the Project located on 23 sites within the City and County of Denver. Four of the proposed locations would contain two well facilities.

All representative well facilities are located on property owned by the City and County of Denver in parks, golf courses, or at the Denver International Airport nursery. Well locations that interfere with park uses or create other conflicts would be avoided. Actual siting of the facilities would occur during pre-construction design and planning, and would include coordination with park or facility managers. The 23 representative well sites and distribution pipeline system layout are shown in Figure 2-15.

The well facility would consist of a well house that contains piping, valves, metering, and motor controls. Figure 2-16 illustrates a general well layout. Figure 2-17 is a photograph of a typical well house. The well house would be approximately 21 by 30 feet. The building would be approximately 16 feet from the ground to the top of the roofline. Two 3 by 3 by 4-foot tall transformers would be located adjacent to the building. Wells/well houses would be located at the perimeter of the park or golf course, minimizing the disruption to the primary use areas within the park or golf course. Individual wells would be equipped with variable frequency drive electric motor driven submersible pumps installed in the well casing, with a pitless adapter to allow connection of the well to power and to the well discharge pipe. Well houses would be used to consolidate the piping from the three wells at each site and to house the required valving and metering needed to combine the three well lines into a single discharge pipe from the site. The well house would also provide a location for motor controls and control panels for all three wells. Architectural treatment would be used to blend the well house into the surrounding setting to soften the visual impact.

Figure 2-16
Typical Well Layout for Proposed Deep Aquifer Storage and Recovery System



Source: MWH, 2006.

Figure 2-17
Typical Well House for Proposed Deep Aquifer Storage and Recovery System

Source: MWH, 2006.

At well locations where there could be potential constraints due to the size, location, and character of the park and surrounding area, a well vault would be installed instead of a well house. The advantage of a well vault is that the structure would be primarily buried, and therefore, not visible to the public. The motor control center and control panel would be located above grade to provide easier access and protect the electrical equipment from water damage. Access to the well vault would be provided through an exposed access hatch. It is assumed that six of the 23 well sites would have well vaults.

The number of wells planned is a function of anticipated recharge and recovery rates. Permanent aboveground well structures would include a 12-inch diameter casing protruding approximately 2 feet above ground level. The top of the casing would have a cover and a vented cap, along with two small junction boxes for power and control equipment. Deep wells require submersible pumps; therefore, pump noise generation during pump operation would be negligible.

Denver Basin Distribution Pipeline

Water would be conveyed to and from the 27 well facilities by a network of pipelines as shown in Figure 2-15. The representative layout includes a total of approximately 36 miles of 12 to 48 inch pipeline, which would be buried in city streets and urban utility corridors within existing road rights-of-way (ROWs)/easements.

Conduit M

Water extracted from the Denver Basin aquifers would be delivered back to the new AWTP. A new pipeline (Conduit M) would be required to deliver water from the new AWTP (where water extracted from the Denver Basin would be collected) to the Moffat Collection System delivery point, which is at the South Boulder Diversion Canal. The conduit would be 36 inches in diameter, approximately 18.5 miles long, and would be constructed within existing roads (curb-to-curb). Conduit M would terminate at the South

Boulder Diversion Canal, similar to Conduit O (refer to Alternative 8a). Figure 2-15 shows the preliminary route of Conduit M.

The pipeline would cross railroad tracks and roads using Denver Water's standard bore and jack method. Crossing the South Platte River and other drainages would be in open cuts per Denver Water's standard practice (refer to Section 2.8.3 for details).

Three pump stations with a capacity of approximately 2,000-horsepower each would be required to deliver recovered groundwater to the Moffat Collection System. One pump station would be located at the AWTP to deliver water to the injection/recovery well field. Pump stations along the pipeline would be located within the pipeline corridor. Typical pump station characteristics would be the same as described for Alternative 8a.

Support Facilities/Staging Areas

Temporary pipeline construction staging areas for stockpiling materials and equipment, worker parking, and field office trailers would be established at several locations along the pipeline route in vacant lots. Staging areas for the AWTP and ASR wells would be on site.

Roads and Access

Existing roads would be used during construction and operation of the ASR well facilities.

Recreational Facilities and Public Access

There are no proposed recreational facilities and no public access to the ASR well facilities.

Utilities, Lighting, and Fencing

Additional power facilities such as transmission lines and substations would be required to support the pumping facilities for Conduit M and the various pipelines. Power would be brought to the wells and well houses/vaults using buried cables.

There would be no perimeter fencing at the well sites. Security lighting would include two low-voltage lamps: one at the well house building entrance and one at the transformers.

2.6.3 Proposed Changes to Denver Water's System Operations

The primary changes in Denver Water's North and South system's operations are described under the Proposed Action (Section 2.3.3), with the following exceptions pertinent to Alternative 10a. Refer to Section 5.1 for details on the proposed hydrologic changes.

Aquifer Storage and Recovery System Operations Plan

Water stored in the Denver Basin aquifers would generally be used for supply in dry years. Based on runoff forecasts and Denver Water reservoir contents, Denver Water would decide in the spring whether or not to recover water from the Denver Basin aquifers for delivery to the Moffat Collection System. When needed, water would be collected and pumped to the Moffat Collection System delivery point via Conduit M.

Deliveries would be made from the Denver Water Recycling Plant to the new treatment plant and then injected into the Denver Basin aquifers to the extent that reusable effluent is available and storage of reusable water in the Denver Basin aquifers is less than 5,000 AF. In years when the stored water is not used, no water would be injected into the Denver Basin aquifers unless needed to recharge the aquifer.

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2.7 ALTERNATIVE 13A – GROSS RESERVOIR EXPANSION (60,000 AF)/TRANSFER OF AGRICULTURAL WATER RIGHTS/GRAVEL PIT STORAGE (3,625 AF)

2.7.1 Introduction/Abstract

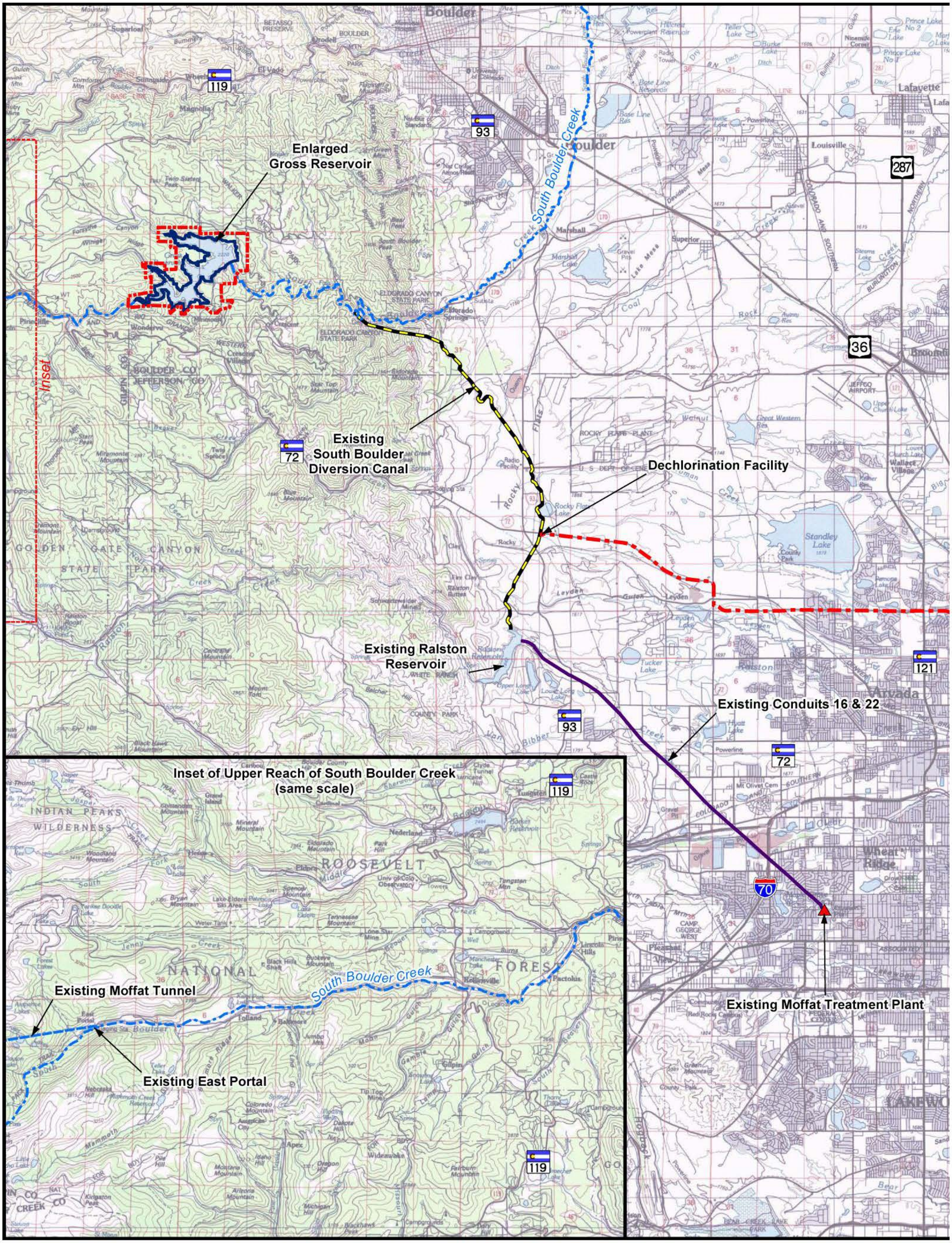
Alternative 13a would combine storage of Moffat Collection System supplies in an expansion of the existing Gross Reservoir with a purchase and transfer of existing South Platte River agricultural water rights stored in gravel pit storage facilities to provide 18,000 AF/yr of new firm yield. Approximately 15,000 AF/yr of new firm yield would be provided by Moffat Collection System supplies and the enlargement of Gross Reservoir, while 3,000 AF/yr of new firm yield would be provided by gravel pit storage and transferred South Platte agricultural water rights.

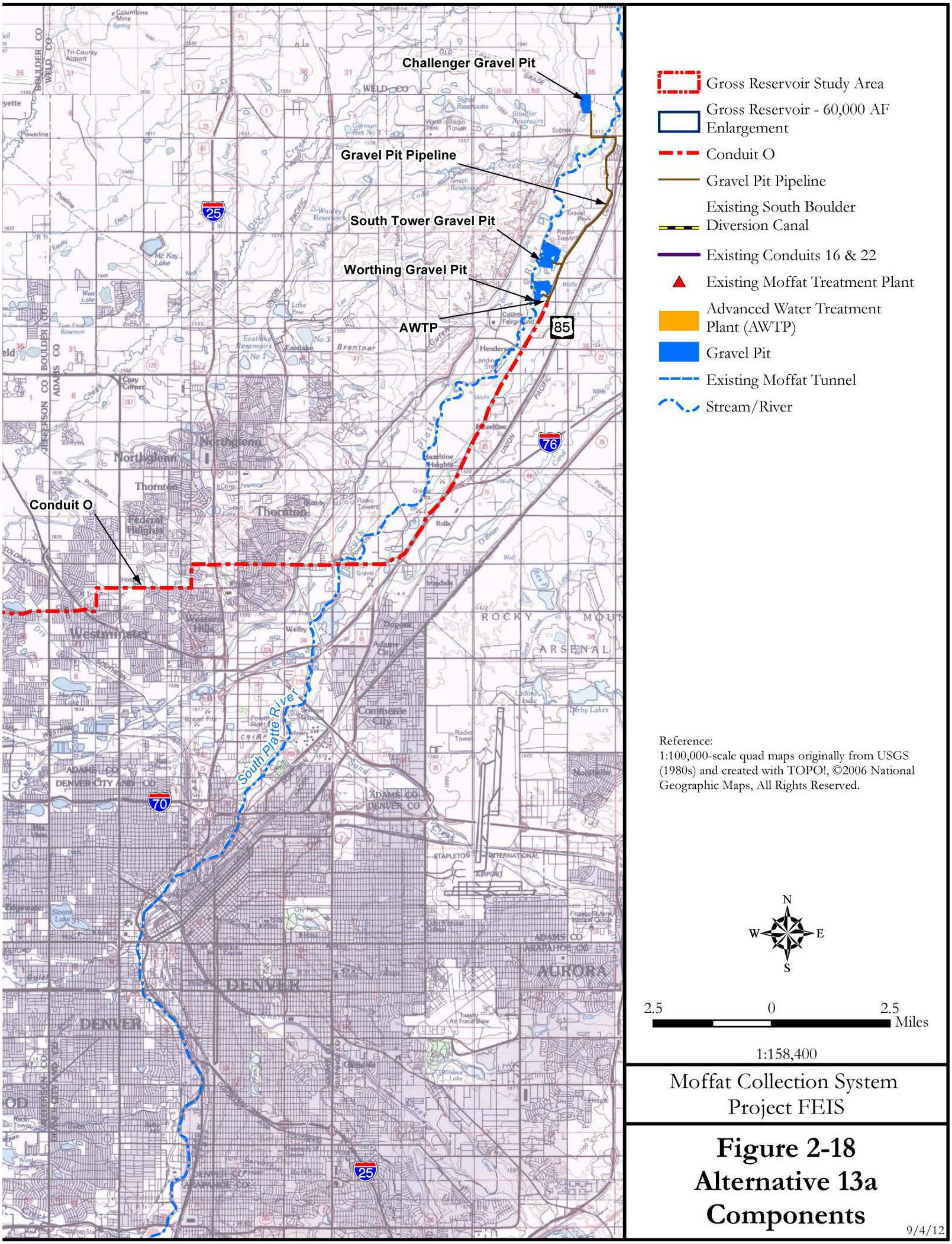
The existing Gross Dam would be raised 110 feet to provide an additional 60,000 AF of new storage capacity in an expanded Gross Reservoir. When available, additional water diverted from the Fraser River, Williams Fork River, and South Boulder Creek at existing Denver Water facilities, under existing Denver Water water rights, would be stored in an expanded Gross Reservoir.

Senior agricultural water rights, owned by ditch companies diverting from the South Platte River downstream of Denver, would be purchased and converted to municipal/industrial use. Water rights sufficient in quantity and priority would be purchased to produce approximately 3,000 AF/yr of firm yield when combined with 3,625 AF of new gravel pit storage. Gravel pit storage is needed to firm the agricultural water rights supply, provide operational storage, and meet winter return flow obligations associated with historical use of the agricultural water rights. A new diversion from the South Platte River, as described in Alternative 8a, would divert water to the gravel pit storage facility.

The gravel pit storage facilities (gravel pits, diversion structure, and pipelines) are considered representative of typical existing facilities found along the South Platte River. The actual location and configuration of the gravel pits, AWTP, and associated facilities would be determined during the design phase should this alternative be permitted by the Corps.

Figure 2-18 displays the Alternative 13a components. Table 2-15 lists the major components of this alternative. Details are presented in the Project Components discussion below.


Enlarged
Gross Reservoir
Existing
South Boulder
Diversion Canal
Dechlorination Facility
Existing Ralston
Reservoir
Existing Conduits 16 & 22
Existing Moffat Treatment Plant
South Boulder Creek
Inset
Inset of Upper Reach of South Boulder Creek
(same scale)
Existing Moffat Tunnel
Existing East Portal
South Boulder Creek



Moffat Collection System Project FEIS

Figure 2-18 Alternative 13a Components

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Table 2-15
Alternative 13a – Primary Components

Facility	Component Description
Gross Reservoir Expansion and Dam Raise	Additional 60,000 AF of storage capacity
	110-foot dam raise
	New concrete spillway over dam raise
	New auxiliary spillway south of dam
	Four construction staging areas
	Relocation of existing recreation and visitation facilities
	Borrow material: approximately 60% of the total borrow material produced on site; up to 40% of fine aggregate obtained from off-site commercial sources
	Relocation of existing dam and spillway access roads
	Two stockpile and spoil areas and associated haul roads
	No modification to existing outlet works
South Platte River Diversion	150-foot long concrete diversion in the South Platte River – representative design
	750-foot, 54-inch pipeline from diversion to gravel pit storage
	Diversion via the existing Brighton Ditch to the Challenger Pit
Gravel Pit Storage	Worthing, South Tower, and Challenger pits – representative sites
	Practical storage volume of approximately 3,625 AF (total of all pits)
	Perimeter slurry wall to prevent groundwater seepage
	5 miles of 30-inch diameter pipeline and pump stations connecting the three gravel pits
	Controlled outlet on at least one pit to meet winter return flow obligation
Advanced Water Treatment Plant	Located near Worthing Pit – representative site
	Process train; sedimentation, low-pressure membrane pretreatment, reverse osmosis, advanced oxidation, disinfection, and zero-liquid discharge
	10.8 mgd capacity
	4-acre plant site and 60-acre evaporating pond/drying beds
Dechlorination Facility	0.1 acre site – representative site
Pipeline (Conduit O)	25 miles, 30-inch diameter pipeline connecting the new Advanced Water Treatment Plant and the Moffat Collection System – representative alignment
	Three 1,500-horsepower pump stations

Notes:
% = percent
AF = acre-feet
mgd = million gallons per day

2.7.2 Project Components

2.7.2.1 Gross Reservoir

The existing Gross Reservoir stores 41,811 AF and has a surface area of 418 acres at elevation 7,282 feet (spillway elevation). Under Alternative 13a, Gross Reservoir would be expanded to approximately 101,811 AF in order to provide an additional 60,000 AF of storage. The proposed reservoir surface area at normal water level would expand to approximately 755 acres inundating approximately 337 acres of surrounding shoreline at elevation 7,385 feet. This enlargement, and associated dam construction, would require Denver Water to obtain FERC approval to amend its existing hydropower license for Gross Reservoir, Project No. 2035.

Water Source

The water source would be the same as for the Proposed Action. Average and wet-year water would be supplied from the existing Moffat Collection System in the Fraser and Williams Fork river basins, and South Boulder Creek. Existing Denver Water water rights would be used. No new water rights would be required.

Dam Features

Under Alternative 13a, the Gross Dam would be raised by 110 feet. This mass concrete dam enlargement would raise the dam crest to a height of 450 feet, at elevation 7,385 feet. The crest length of the enlarged dam would be 1,753 feet and would have a width of 25 feet. The raised dam would have approximately the same dam axis, arch radius, crest width, and downstream slope as the existing dam section. The upstream and downstream slopes of the raised dam portion would be similar to the Proposed Action. Figure 2-4 shows the profile and sections of the Gross Dam. Table 2-11 provides a comparison of the proposed Gross Dam and Reservoir features with the existing facility.

Foundation Preparation and Excavation
Foundation preparation and excavation would be the same as the Proposed Action, except that the approximate depth of excavation and the depth of the grout curtain would be less.

Spillways
Spillways would be the same as the Proposed Action, except that the crest elevations of the spillway (elevation 7,385 feet) and auxiliary spillway would be lower.

Tree Removal
Tree removal for Alternative 13a would be the same as for the Proposed Action, except a smaller area would need to be cleared between elevation 7,282 and 7,395 feet (10 feet above the elevation for the 60,000-AF enlargement).

Other Components

Other components of Alternative 13a that are similar to those described under the Proposed Action include the following (refer to the Proposed Action, Section 2.3.2 for details):

- Inlet and Outlet Works

- Borrow/Embankment Materials
- Support Facilities/Staging Areas
- Roads and Access
- Public Access and Recreational Facilities
- Reservoir Delivery Infrastructure
- Utilities, Lighting, and Fencing
- Hydroelectric Facility

2.7.2.2 Proposed Gravel Pit Storage Facilities

Agricultural water supply would be diverted from the South Platte River and stored in gravel pit reservoirs, similar to Alternative 8a. Given the typical size of gravel pits along this reach of the South Platte, several gravel pit storage sites would be required to develop the volume of storage necessary to generate additional firm yield for Denver Water. Storage is required to firm the agricultural water supply in order to meet Denver Water's demand schedule through the critical period, as well as to provide operational storage and meet winter return flow obligations incurred through the water right transfer process. For purposes of this EIS analysis, three existing gravel pits, the Worthing, South Tower, and Challenger, were identified as representing one combination of pits that would provide the approximately 3,625 AF of new gravel lake storage required for this alternative (Figure 2-19) (Boyle 2006b).

Similar to Alternative 8a, for the purposes of this EIS analysis, these gravel pits were considered representative of gravel pit storage along the South Platte River. The final combination of gravel pits would be determined during the design phase should this alternative be permitted. It is also assumed that when Denver Water acquires the gravel pits they would be completely mined and reclaimed for use as a water storage facility (refer to Figure 2-11 under Alternative 8a). The gravel pits would be connected hydraulically using a system of pump stations and pipelines; this system is described in further detail below.

Water Source

Four ditches have their head gates on the South Platte River between Denver and the City of Brighton: the Fulton Ditch, Brantner Ditch, Brighton Ditch, and Lupton Bottom Ditch. This reach of the river is a preferable source of historical agricultural water because of its proximity to Denver. Because this alternative requires availability of willing sellers, the actual location of acquired water rights could include ditches located further downstream. Each of these ditches are operated by individual mutual ditch companies, whereby shareholders receive their pro-rated share of the waters diverted by the ditch based on the number of shares they own in the ditch company. These ditch systems all have water rights that were originally decreed to provide agricultural irrigation water. With growing pressures for water supplies for the Front Range urban area, an increasing number of shares in these systems have been purchased and changed, through a Water Court procedure, from irrigation to municipal use. Approximately 3,000 AF/yr of new firm yield would be provided by transferred agricultural water rights. For the purposes of this EIS analysis, these ditches and the associated water rights were considered representative of agricultural ditches along the South Platte River. The amount of transferred agricultural water included in Alternative 13a was based on a review of water rights, costs associated with purchasing agricultural water rights, treatment and conveyance costs associated with South Platte River water, and potential water quality issues associated with blending those supplies with Moffat Collection System supplies. The final configuration of this alternative would be determined during the design phase should this alternative be permitted.

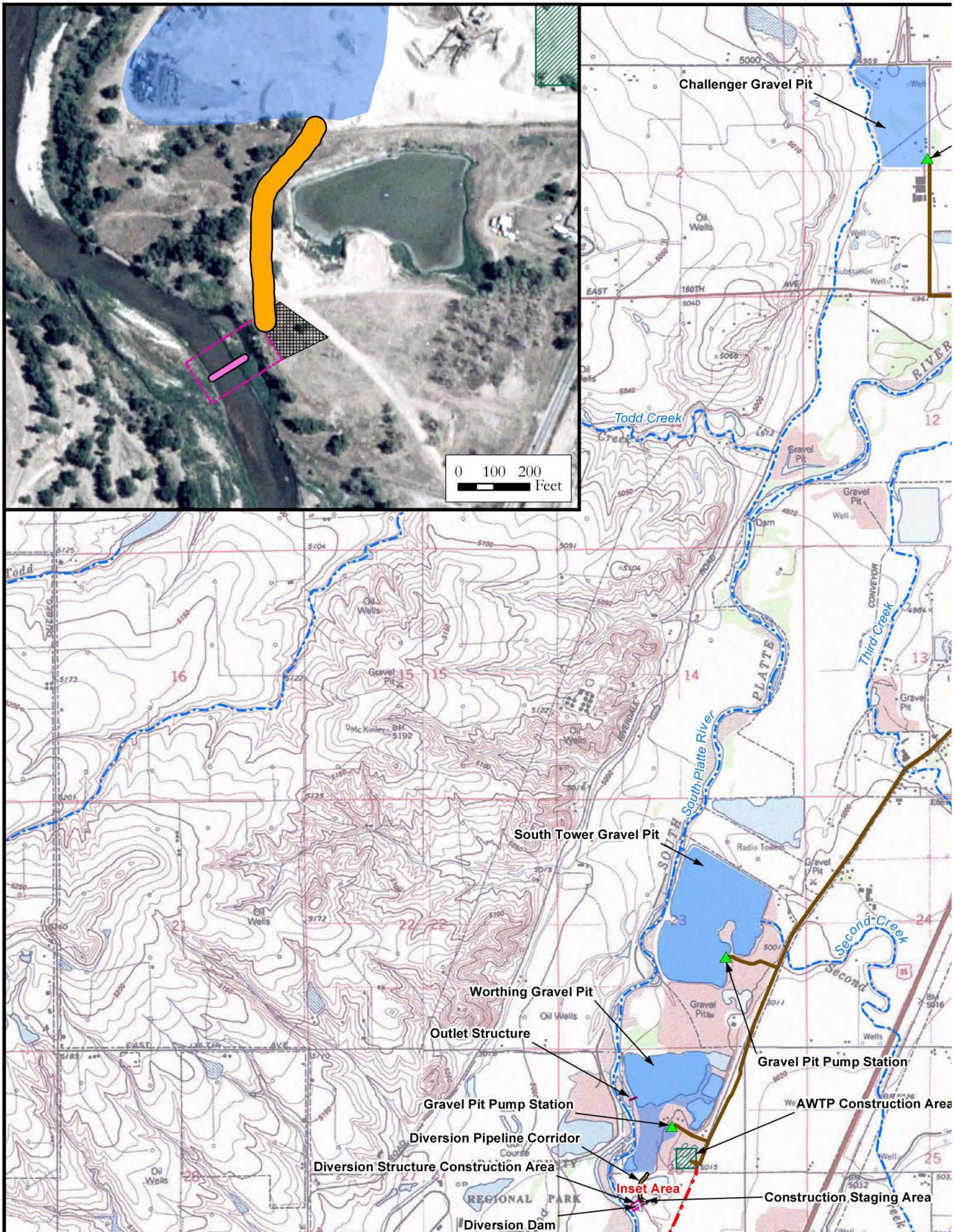
The yield of shares in these ditches varies depending on the historical practices of the specific farmers whose shares are purchased (Boyle 2006b). However, analysis shows that approximately 3,000 AF of firm yield (i.e., during dry years) could be acquired if Denver Water purchases approximately 24% of the shares of each ditch that currently remain in agriculture. Denver Water would have to obtain a "change decree" from Division 1 Water Court for the acquired portions of the water rights owned by the ditches. The decree process involves quantifying the historical use of the water right, identifying the new location and pattern of use, demonstrating that the change will result in no greater depletion of the river than that caused by the historical irrigation use, and incorporating limits and conditions on the new use that will protect others from injury.

The change in water rights would carry with it an obligation to replicate the lagged return flows that occurred when the water was historically used for irrigation. These contributions to the river occur during the non-diversion season. Thus, one function of the gravel pits would be to store water during the diversion season for release during fall and winter months to meet return flow obligations in accordance with the change decree.

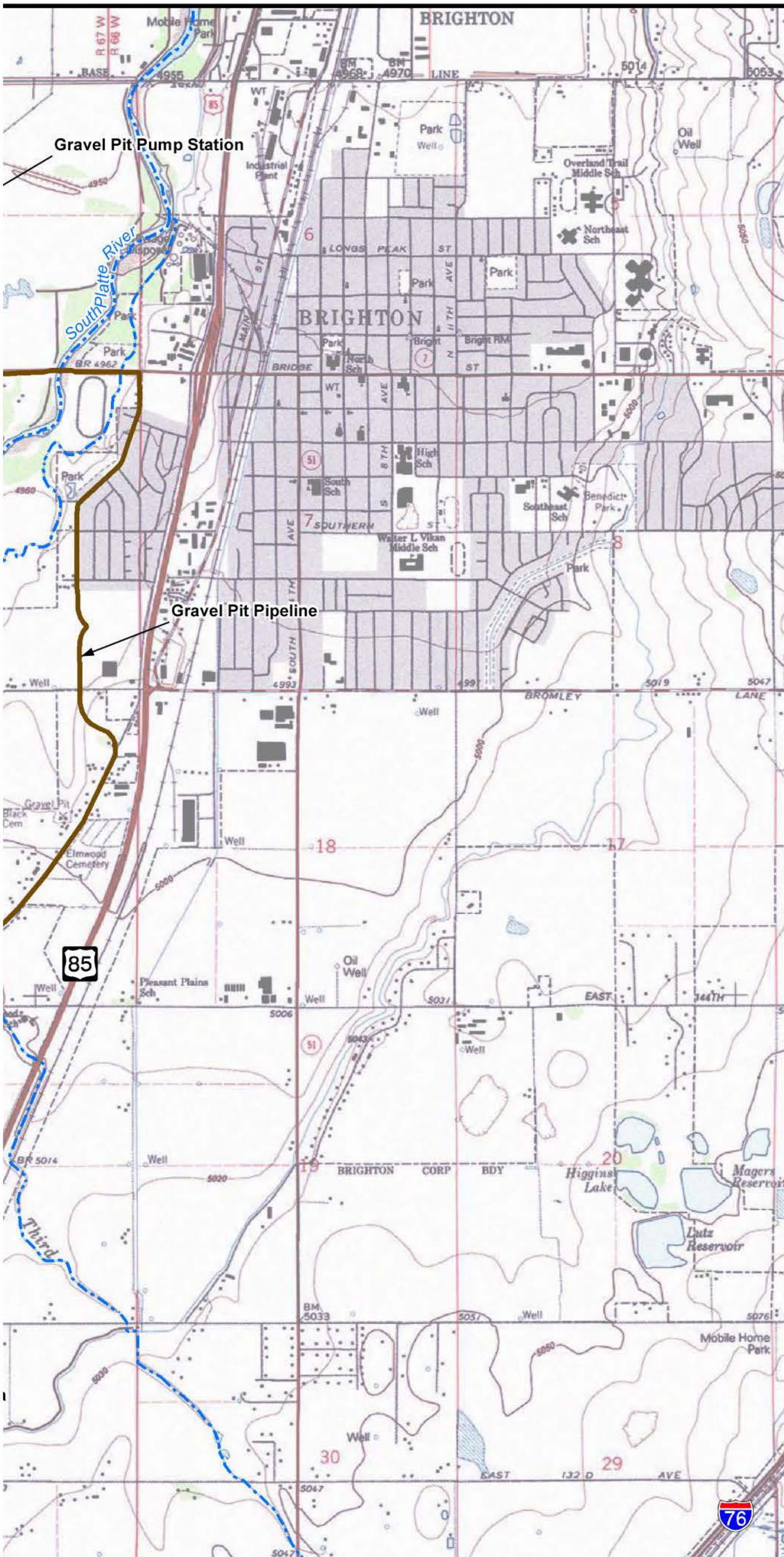
Another outcome of the change in water rights would be the dry-up of lands irrigated historically by the changed water rights. The land to which the water was once applied would be required by the Water Court to be formally taken out of production. It is estimated that approximately 3,900 acres of agricultural land would be taken out of irrigation. However, the actual amount would depend on what agricultural shares would be purchased and the historical practice on those lands.

Outlet Works

A controlled outlet to the river to meet winter return flow obligations would be included in the design. Note that this feature is an additional requirement relative to the gravel pits described in Alternative 8a, for which there is no requirement to release water to the river.



0 100 200
Feet
Challenger Gravel Pit
Todd Creek
South Platte River
Third Creek
Second Creek
South Tower Gravel Pit
Worthing Gravel Pit
Outlet Structure
Gravel Pit Pump Station
Gravel Pit Pump Station
AWTP Construction Area
Diversion Pipeline Corridor
Diversion Structure Construction Area
Inset Area
Construction Staging Area
Diversion Dam



- Gravel Pit Pipeline
- Conduit O
- Gravel Pit Pump Station
- Outlet Structure
- Diversion Dam
- Diversion Pipeline Corridor
- Construction Staging Area
- Diversion Structure Construction Area
- Advanced Water Treatment Plant (AWTP) Construction Area
- Gravel Pit
- Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Aerial photography from USDA (2005).

N
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2,500 0 2,500 Feet

1:30,000

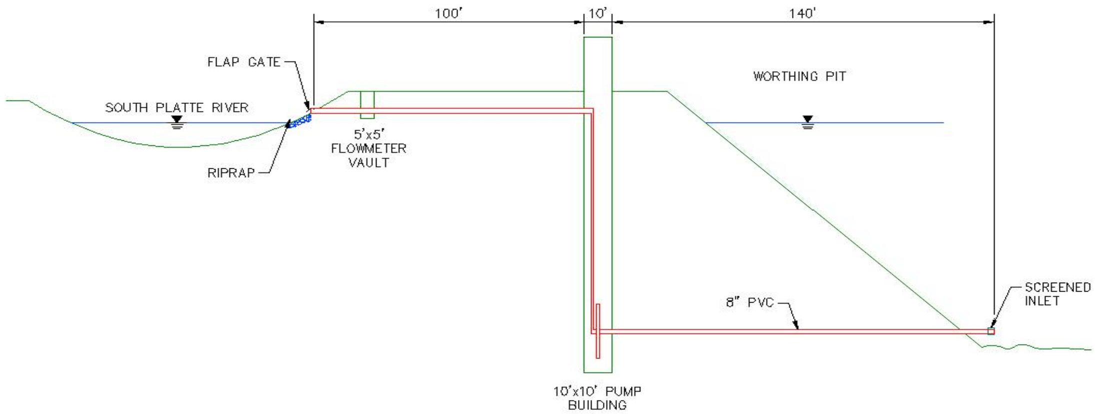
Moffat Collection System Project FEIS

Figure 2-19
Alternative 13a
Typical Gravel Pit Storage Facilities

9/4/12

Using the Worthing Pit as an example, a single pump would be housed in a 10 by 10 by 8-foot tall building between the Worthing Pit and the South Platte River with an 8-inch inlet pipe and an 8-inch discharge pipe. A flow meter would be housed in an approximately 5 by 5 by 6.5-foot deep vault downstream of the pump building. Flows would discharge through a flap gate onto a 5 by 5 foot area of riprap. The outlet invert elevation would be located above the South Platte River's normal winter flow level. A plan view of a typical outlet structure is shown in Figure 2-20.

Figure 2-20
Typical Outlet Structure



Source: Boyle, 2006c.

Diversion Structure

The proposed diversion structure would be the same as described in Alternative 8a (Figure 2-12). Water diverted from the South Platte River would fill the Worthing Pit, from which the South Tower Pit would be filled. Because of the interconnections among the gravel pits, the Challenger Pit could be filled from the South Tower Pit, but the more typical operation would be to deliver water to the Challenger Pit by way of the existing Brighton Ditch. It is expected that improvements to the Brighton Ditch would not be required because the water being carried to the Challenger Pit replaces water transferred from the Brighton Ditch by virtue of the purchase and change of Brighton Ditch shares.

Gravel Pit Pipeline

The gravel pits would be connected by a 5-mile long, 30-inch diameter bi-directional pipeline and associated pump stations. The buried pipeline would run south from the southeast corner of the Challenger Pit along existing roads to the Worthing Pit and the new AWTP (Figure 2-18). Lateral pipelines would be installed connecting each gravel pit to the 30-inch pipeline. The interconnecting pipeline would be used to fill the gravel pits with water diverted from the South Platte. When needed, water would be pumped from each pit into the interconnecting pipeline and conveyed to the new AWTP.

Similar to Alternative 8a, three pump stations (one at each gravel pit storage facility), with a capacity of 2,000-horsepower each, would be required to deliver water from the gravel pit storage facilities to the new AWTP.

Advanced Water Treatment Plant

Under Alternative 13a the AWTP would be the same as described for Alternative 8a, except that the capacity would be less—10.8 mgd versus 13.6 mgd in Alternative 8a. The off-site disposal facility would be slightly smaller due to the smaller plant capacity. The 10.8 mgd plant would require approximately 60 acres (versus 70 acres) of evaporation ponds and drying beds.

Conduit O

Same as Alternative 8a, except the pipelines would be smaller (30-inch diameter versus 36 inches).

Other Features

Other features of Alternative 13a that would be the same as under Alternative 8a include the following (refer to Section 2.5.2.2 for details).

- Dechlorination Facility
- Support Facilities/Staging Areas
- Roads and Access
- Recreation and Public Access
- Utilities, Lighting, and Fencing

2.7.3 Proposed Changes to Denver Water's System Operations

The primary changes in Denver Water's North and South system's operations are described under the Proposed Action (Section 2.3.8), with the following exceptions pertinent to Alternative 13a. Refer to Section 5.1 for details on the proposed hydrologic changes.

Proposed Gravel Pit Storage

Water stored in the gravel pits would generally be used for supply in dry years and delayed return flows. Based on runoff forecasts and Denver Water reservoir contents, Denver Water would decide in the spring whether or not to draw from the gravel pits for delivery to the Moffat Collection System. If needed, the water would be delivered to the Moffat system as limited by treatment and conveyance capacity. Diversions would be made from the river to the pits to the extent that water is physically and legally available under the purchased water rights. In years when the stored water is not used, water would be taken under the purchased rights only to replace evaporative losses and return flow obligations. In every year, the gravel pits would release to the river from October through March, to fulfill winter return flow obligations in accordance with the change decree. Typically, the release requirement would be based on the total volume diverted during the previous diversion season.

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2.8 CONSTRUCTION ACTIVITIES FOR ALL ACTION ALTERNATIVES

The designs for all Moffat Project alternatives, including the proposed 131-foot dam raise under the Proposed Action, are conceptual and will be further developed based on permitting decisions by the Corps and FERC. Construction-related information such as schedules, equipment, manpower needs, etc. is approximate based on conceptual-level designs, but is sufficient for purposes of the environmental analyses in this EIS.

2.8.1 Schedule and Sequencing

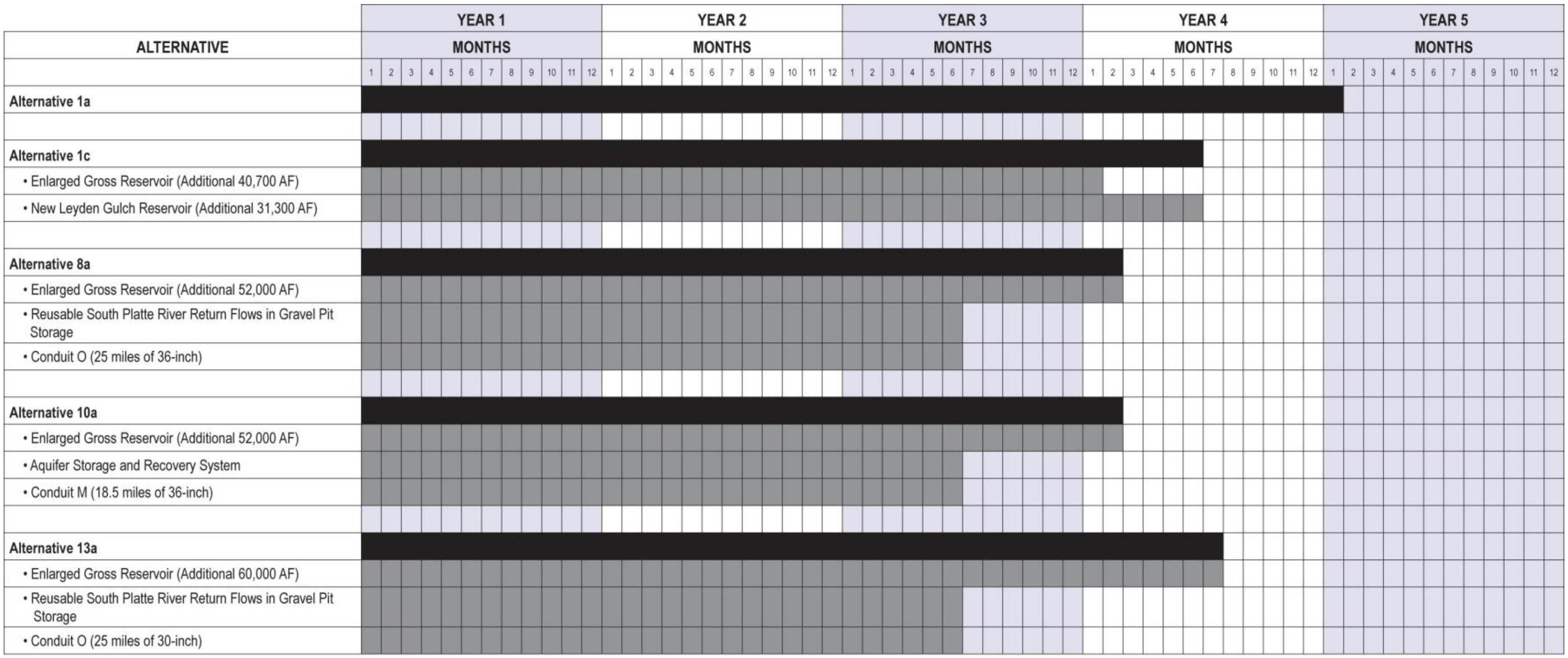
Construction of all Project facilities would occur year-round. The estimated construction period varies for each of the action alternatives from approximately 3 years for Alternatives 8a and 10a to approximately 4 years for the Proposed Action. Refer to Table 2-16 for the estimated construction schedule for each action alternative. Detailed construction schedules are provided in Appendix D-1. Most construction would likely occur during the day, however, double or triple shifts up to 24 hours per day operation are likely. Work hours for all construction would be limited in conformance with applicable local ordinances. Due to the short construction schedule and the substantial scope of the Project, construction activities would be performed concurrently where possible.

The schedule would vary for certain activities such as the following:

- Concrete placement at Gross Dam and other facilities would likely take place primarily within the April through November period, when temperatures are generally above freezing.
- Major conduit construction would occur at production rates ranging from about 500 to 1,200 feet per day depending on localized conditions, so that a particular stretch of roadway would typically be impacted by pipeline construction for less than 1 week.
- Construction of the distribution pipeline associated with the Denver Basin deep aquifer storage (Alternative 10a) would vary by location and by the diameter of pipe, but would average approximately 25 to 35 days per mile for in-street construction.
- Well drilling (Alternative 10a) would average 2 weeks per well. The three injection/ recovery wells at each site would be drilled consecutively. The construction time of each well house would range between 30 to 60 days and would initially coincide with the well drilling activities.
- Denver Water would not change how Gross Reservoir is operated as a result of construction activities. In general, Gross Reservoir reaches its lowest capacity in March or April and fills by mid-July. The reservoir is kept as full as possible until water demand exceeds available water supply, typically mid-August. The reservoir is then drawn down throughout the fall and winter until the following spring.

Denver Water anticipates that final design and permitting would begin upon receipt of the Section 404 Permit. Construction activities would take place upon completion of final design and receipt of FERC approval to begin construction. Operation of the facility would begin upon completion of construction activities.

Table 2-16
Estimated Construction Schedule by Alternative



Note: Construction includes mobilization, construction of alternative components, testing and commissioning, reclamation, and demobilization.
The construction timelines at Gross Reservoir also includes establishment of recreational facilities.
Construction timelines assume all permits are in place.

The general construction sequence for the various components of the EIS action alternatives is assumed to include the typical activities listed in Table 2-17.

Table 2-17
Typical Construction Sequences

Gross Reservoir Dam Raise • Mobilization • Clearing and grubbing • Excavation • Foundation treatment • Aggregate processing • Concrete placement • Auxiliary spillway • Slope protection • Demobilization	**Leyden Gulch Dam and Reservoir** • Mobilization • Clearing and grubbing • SH 93 relocation • Outlet works • Excavation • Foundation treatment • Embankment construction • South Boulder Diversion Canal reroute • Slope protection • Demobilization
AWTP and Pump Stations • Mobilization • Clearing and grubbing • Excavation • Concrete placement • Piping and below-grade utilities installation • Above-grade structure construction • Mechanical and electrical equipment installation • Controls system installation • Testing and commissioning • Landscaping • Demobilization	**Pipelines** • Mobilization • Rights-of-way clearing and preparation • Pipe stringing • Trenching • Pipe installation • Inspection and protective wrapping • Backfill, repave, or regrade, and revegetate as applicable • Hydrotest and commission • Demobilization
Denver Basin Aquifer Wells • Mobilization • Well drilling • Well house construction • Pump and motor installation • Electrical equipment installation • Controls system installation • Testing and commissioning • Landscaping • Demobilization	

2.8.2 Temporary Sediment and Erosion Control

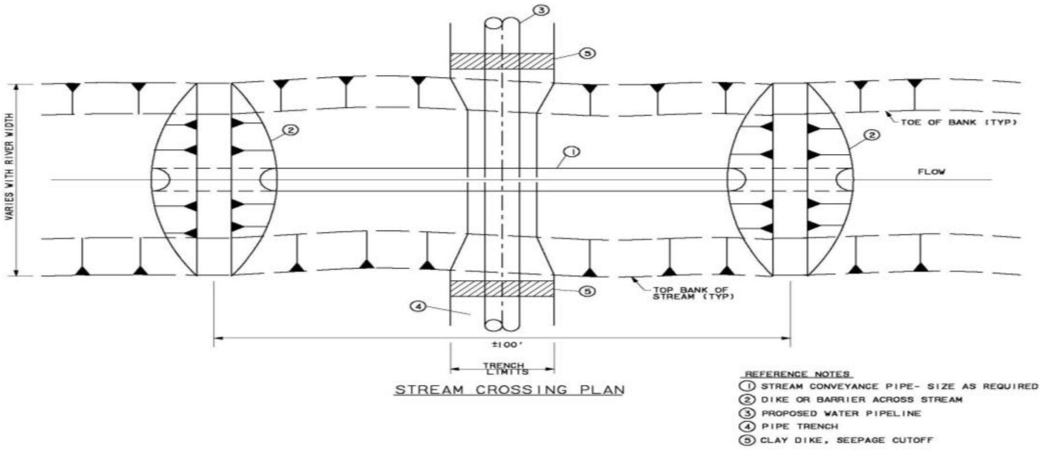
Prior to construction, Denver Water, or its contractor, would obtain a Stormwater Discharge Permit for Construction Activities from the Colorado Department of Public Health and Environment. The permit would require development of a specific stormwater management plan to prevent and control erosion from stormwater runoff and subsequent downstream water quality degradation. The permit and plan would remain in effect until the exposed areas have been revegetated and stabilized. This proposed approach for sediment and erosion control is the same for all EIS alternatives.

Also, prior to construction, Denver Water would need to have its erosion and sediment control plans and other construction-related environmental protection, mitigation, and restoration plans approved by the FERC’s Division of Dam Safety and Inspections.

2.8.3 Pipeline Construction Methods

The proposed pipelines associated with the alternatives include Conduit O (36- and 30-inch diameter), Conduit M (36-inch), gravel pit pipelines (36-inch), and ASR distribution pipelines (18- to 48-inch). The various pipelines would cross highways, railroads, and streams. Crossings of railroads and major State and interstate highways would be bored and jacked per Denver Water’s standard practice. All pipeline crossings of streams and ditches would be open cut per Denver Water's standard practice. Figure 2-21 shows a typical stream crossing. The assumed construction corridor would be 160 feet wide at stream crossings. Typically, a semicircular earthen dike would be constructed to confine the river flow to half of the natural channel. The dry half of the channel would be trenched, the pipeline would be installed and the trench would be backfilled. The dike would then be removed and a new dike would be constructed to confine the river flow to the other half of the channel. The remaining trench would be excavated, the pipeline installed, and the trench backfilled, as before. The second dike would be removed and the site would be restored to its approximate original condition. Each crossing would be completed within approximately 20 working days depending on weather and flow conditions. Standard sediment and erosion control would be used at all construction sites.

Figure 2-21
Typical Stream Crossing



Source: MWH, 2006.

2.8.4 Construction Equipment

A wide variety of machinery would be used in the performance of the construction work for each alternative, such as scrapers, loaders, dozers, compactors, rollers, track hoes, and back hoes. Table 2-18 lists the primary on-site construction equipment necessary to support each of the EIS alternatives. The construction equipment would travel little or no mileage off site on public roads, but they would be running full time during construction activities.

2.8.5 Construction Traffic

It is estimated that construction-related traffic would consist of two general categories of traffic:

1. **Gross Reservoir Expansion:** Haul trucks (15 cy capacity) would import borrow material on public roads from off-site locations 260 days per year. It is assumed that for the Gross Reservoir enlargement component of each alternative, 60% of all concrete material would be found on site, and 40% (aggregate, flyash, and cement) would be hauled from an off-site location. Commercial suppliers in the Longmont area are assumed for purposes of the EIS analysis (48 miles one-way between Gross Reservoir and Longmont). In addition, flyash and cement would be hauled to Gross Reservoir and the trucks associated with these materials are included in the estimate for haul trucks in Table 2-19. Transporting borrow material from off-site locations would not be required to construct Leyden Gulch Reservoir or the other facilities proposed in the other alternatives.
2. **Commuting Workers for all Alternatives:** Workers commuting to the various construction sites were estimated based on manpower estimates (refer to Section 2.8.6) and an average carpooling of 1.5 workers per vehicle. In addition, various supply trucks would make daily trips to the construction sites to deliver materials.

Table 2-18
Estimated On-Site Construction Equipment

Type of Equipment	Proposed Action	Alternative 1c		Alternative 8a			Alternative 10a			Alternative 13a		
	Gross Reservoir	Gross Reservoir	Leyden Gulch Reservoir	Gross Reservoir	Conduits	South Platte River Facilities	Gross Reservoir	Conduits	Denver Basin Aquifer Facilities	Gross Reservoir	Conduits	South Platte River Facilities
Air compressor	1	1	1	1	1	1	1	1	1	1	1	1
Backhoe	2	2	2	2	1	1	2	1	1	2	1	1
Compactor	2	2	2	2	1	1	2	1	1	2	1	1
Crane	-	-	-	-	1	1	-	1	1	-	1	1
Dozer	2	2	2	2	-	-	2	-	-	2	-	-
Dump truck	8	8	4	8	-		8	-	1	8	-	-
Front end loader	-	-	4	-	-	-	-	-	1	-	-	-
Fuel truck	1	1	1	1	1	1	1	1	1	1	1	1
Generator, diesel	2	2	2	2	1	1	2	1	1	2	1	1
Motor grader	1	1	4	1	-	-	1	-	-	1	-	-
Pickup truck	10	10	10	10	4	4	10	4	6	10	4	4
Pile driver	-	-	-	-	-	-	-	-	-	-	-	-
Scraper	8	8	8	8	-	-	8	-	-	8	-	-
Water truck	1	1	4	1	1	1	1	1	1	1	1	1
Welder	1	1	1	1	1	1	1	1	1	1	1	1
Tunnel boring machine	-	-	1	-	-	-	-	-	-	-	-	-
Well drilling rig	-	-	-	-	-	-	-	-	1	-	-	-
Total	**39**	**39**	**46**	**39**	**12**	**12**	**39**	**12**	**17**	**39**	**12**	**12**

Source: Denver Water, 2006b.

Table 2-19 shows the estimated vehicle trips averaged over the total estimated construction period for each alternative. Truck traffic for alternative components other than Gross Reservoir is likely to be sporadic and dispersed. For example, the alternatives with advanced water treatment would require less than a truck per day on average.

Table 2-19
Estimated One Way Vehicle Trips

Types of Vehicles	One Way Vehicle Trips by Alternative				
	1a	1c	8a	10a	13a
Gross Reservoir Haul Trucks – Daily Average (Peak Day)	22 (37)	17 (28)	21 (35)	21 (35)	21 (34)
Commuting Worker Vehicles – Daily Average (Peak Day)	60 (101)	193 (319)	175 (301)	228 (382)	159 (247)

Source: Denver Water, 2006c; Harvey Economics, 2007, 2008.

2.8.6 Construction Manpower Estimate

Construction activities associated with each of the alternatives would provide temporary employment for full-time workers. Employment would occur over different periods of time for each alternative. In general, the labor force would consist of heavy equipment operators, general laborers, carpenters, ironworkers, surveyors, and electricians. It is assumed that the majority of the labor force would be hired locally (within a 60-mile radius of the various construction sites). Non-local workers would seek housing in the Denver Metropolitan area. The work force at the various construction sites would vary depending on the phase of construction. Most work would be performed during the day; however, double or triple shifts up to 24 hours per day operation would be likely. Table 2-20 shows the estimated number of workers by component for each action alternative, including a 20% contingency.

Table 2-20
Construction Manpower Estimate
(Full-time Equivalent Workers)

Construction Schedule	Alternatives				
	1a	1c	8a	10a	13a
Year 1					
1st Quarter	16	50	65	70	48
2nd Quarter	32	113	118	150	90
3rd Quarter	47	163	169	213	125
4th Quarter	60	214	268	303	160
Year 2					
1st Quarter	91	325	371	442	239
2nd Quarter	121	438	413	521	319
3rd Quarter	132	475	451	573	345
4th Quarter	142	478	451	572	371

Table 2-20 (continued)
Construction Manpower Estimate
(Full-time Equivalent Workers)

Construction Schedule	Alternatives				
	1a	1c	8a	10a	13a
Year 3					
1st Quarter	151	478	397	558	371
2nd Quarter	151	445	306	384	371
3rd Quarter	146	364	235	349	305
4th Quarter	121	282	166	267	239
Year 4					
1st Quarter	95	251	118	187	187
2nd Quarter	73	134	109	130	134
3rd Quarter	53	104	N/A	N/A	112
4th Quarter	44	N/A	N/A	N/A	90
Year 5					
1st Quarter	43	N/A	N/A	N/A	N/A
Daily Average	90	290	263	342	239
Quarterly Peak	151	478	451	573	371
Total Wages (millions)	**$25.0**	**$69.6**	**$61.7**	**$77.5**	**$58.0**

Source: Denver Water, 2006c; Harvey Economics, 2007, 2008.
Note:
N/A = not applicable

2.8.7 Post-Construction Activities for All Action Alternatives

Post-construction, the daily workforce required to operate and maintain the proposed Project facilities would not change from existing conditions. It is assumed that the current staff at the Gross Reservoir facility would be adequate to maintain the enlarged facility. The current staff at the Ralston Reservoir facility would maintain a Leyden Gulch Reservoir facility. The other facilities (ASR wells, gravel pit storage facilities, WTP, pump stations, and dechlorination facility) would operate only during dry years or emergencies. The staff needed to operate these facilities would come from within the existing Denver Water facilities when needed.

2.9 ESTIMATED COST OF ALTERNATIVES

2.9.1 Action Alternatives

Capital costs for construction were developed from feasibility-level designs of the components for each alternative. These costs include materials, supplies, labor, contractor mobilization, and contractor overhead. Contingency factors and engineering costs are also incorporated into capital costs. Costs associated with ROW acquisitions or easements are not included in the construction costs. Fixed annual O&M costs are those associated with physically maintaining the Project facilities, operational costs including the cost of power, and the routine replacement of mechanical equipment. The estimated costs are indexed to January 2006 conditions. Capital and O&M costs associated with each alternative are summarized in Table 2-21 and discussed in Section 5.19.

Table 2-21
Summary of Estimated Costs of Each Action Alternative

Costs	Alternatives				
	1a	1c	8a	10a	13a
Total Capital Construction Costs	$139.9 million	$293.7 million	$362.0 million	$393.2 million	$426.7 million
Annual O&M Costs	$291,000	$612,000	$4.9 million	$6.0 million	$3.9 million
Present Worth of Annual O&M (for an 80-year period, discounted at 3 percent)	$8.8 million	$18.5 million	$147.7 million	$181.5 million	$118.4 million
Total Present Worth Cost	**$148.7 million**	**$312.2 million**	**$509.7 million**	**$574.7 million**	**$545.1 million**

Source: Denver Water, 2006d; Harvey Economics, 2007, 2008.
Note:
O&M = operation and maintenance

Present worth calculations of total O&M costs represent the value at 80 years of annual O&M costs in 2006 dollars. Total present worth costs allow for a simplified comparison of total costs among alternatives accounting for annual as well as upfront costs. Components of total capital construction costs are used to estimate economic output for each alternative, as discussed in Section 5.19. Annual O&M costs are incorporated into the water rates analysis for each alternative. Impacts to water rates are also discussed in Section 5.19.

2.9.2 No Action Alternative

The No Action Alternative would have no direct and clearly discernible costs to Denver Water since facility construction or purchases are not contemplated. In attempting to meet future demands with existing facilities, it is possible that additional operational costs for pumping or treatment might occur, but such costs would be episodic and not given to prediction.

By depleting the Strategic Water Reserve and instituting water restrictions with greater frequency and severity, Denver Water and its customers would experience a host of indirect costs. These are addressed in Section 5.19.

2.10 NO ACTION ALTERNATIVE

2.10.1 Introduction/Abstract

NEPA requires that the EIS alternatives analysis include the alternative of "no action" (40 CFR 1502.14[d]). The CEQ explains that "No Action" means "the proposed activity would not take place and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward" (CEQ 1981).

For this EIS, the No Action Alternative considers what Denver Water would do to meet its Purpose and Need if it does not obtain a Section 404 Permit for the Moffat Project. The No Action Alternative is one that "results in no construction requiring a Corps permit" (33 CFR 325 Appendix B). In the event that a Section 404 Permit is not issued, Denver Water would continue to develop and implement its conservation, non-potable recycling, system refinements and cooperative action projects as described in the 2002 Integrated Resources Plan (IRP) (Denver Water 1997, 2002a). Refer to Section 1.4 for details of this plan. Assuming these projects and activities are fully implemented, demand on the Denver Water system is still projected to exceed supply in the near future (currently estimated around 2022), as shown in Figure 1-5 in Chapter 1.

Consistent with the action alternatives, the No Action Alternative is based on the following assumptions and conditions (refer to Section 5.1 for further details):

- Hydrologic modeling of the No Action Alternative is based on the same future water demands as the action alternatives (363,000 AF/year by the year 2032). The demand includes the 3,000 AF of firm yield for the City of Arvada.
- All water system improvements designed to provide additional sources of water supply through approximately 2022 currently planned and under development are accomplished. Examples include the non-potable recycling project and downstream gravel pit storage (refer to Section 1.4.3).
- Demand projections assume 100% success in implementing Denver Water's conservation goals identified in the 2002 IRP.
- There is no Colorado River Compact Call. The 1922 Colorado River Compact requires the Upper Division States, which includes Colorado, to not deplete the flow of the Colorado River below specified amounts. In order to assure compliance with this term, some believe a Colorado River Compact Call may be imposed, which would require curtailment or cessation of diversions to satisfy downstream compact flow requirements.
- The treated and raw water systems would always operate error-free.
- The No Action Alternative has the same interpretation of water rights, agreements, and permit requirements as the action alternatives.
- Hydrologic modeling of the No Action Alternative is based on the same water supply study period (1947 to 1991) as the action alternatives. The modeling does not include

the severe droughts evidenced by tree-ring-based hydrology studies, nor does it include potential adverse changes due to climate change.

As compared to past droughts when Denver Water's estimated water supply exceeded demand, under the No Action Alternative there is no water supply surplus. During the recent 2002 to 2005 drought period, Denver Water's average annual water supply was 315,000 AF, and the average unrestricted customer demand was 285,000 AF/yr. Denver Water's estimated average annual surplus was 30,000 AF (315,000 AF minus 285,000 AF). However, droughts occur with unpredictable intensity and duration. During drought events, it is unknown how long the drought will last or how severe it will be, and drought periods more severe than the 1947 to 1991 study period can be expected. Even though Denver Water had an estimated surplus during the recent drought, they enacted mandatory restrictions on their customers' use of water. Under the No Action Alternative, Denver Water's average annual demand is 75,000 AF greater than the demand during the recent drought (360,000 AF minus 285,000 AF). The 360,000 AF/yr of demand does not include Arvada's additional demand of 3,000 AF/yr. This represents a 26% increase in demand; however, supplies are only estimated to increase by 30,000 AF/yr on average by 2022. The demand under the No Action Alternative would be even higher except that conservation is expected to produce an additional 16,000 AF/yr of annual savings. The 16,000 AF/yr of conservation savings is expected every year and is not available as an additional savings due to drought restrictions. This "demand hardening" will make it more difficult for customers to save water during restrictions. With 75,000 AF/yr of additional demand and the expected demand hardening, the No Action Alternative would require more frequent and severe restrictions.

The No Action Alternative would require Denver Water to use a combination of strategies to meet the need for additional water supply, including using a portion of its Strategic Water Reserve (described in Section 1.4.1.5) and imposing more frequent and severe mandatory restrictions than the action alternatives to help reduce demand during drought periods. However, these strategies would not resolve the system vulnerabilities, flexibility, or reliability problems identified in the Purpose and Need.

2.10.2 Project Components

Only those potential strategies that did not require a Corps permit were considered as possible components of the No Action Alternative. Numerous non-structural or institutional water management concepts were considered in the preliminary alternatives screening process, including buying back contract commitments, integrating operations with other water supply providers, expanding reuse, etc. (refer to Appendix B for the list of concepts considered). These non-structural concepts were evaluated and eliminated from further consideration for the No Action Alternative because they did not meet the Purpose and Need. In addition, certain components of Alternatives 8a, 10a, and 13a, such as agricultural transfers and reusable supplies, were considered in formulating the No Action Alternative. However, the implementation of these elements with respect to storage and conveyance would likely require a Corps permit. Because all these non-structural and other components either did not meet the Purpose and Need or would require a Corps permit, Denver Water identified two alternative potential No Action strategies that could only address the water supply portion of the Purpose and Need. However, these strategies would not resolve the system vulnerabilities, flexibility, or reliability problems identified in the Purpose and Need.

Denver Water's existing water rights and facilities can meet an average unrestricted demand up to 345,000 AF/year, while maintaining the 30,000 AF/year of yield in the Strategic Water Reserve. It is currently estimated that beginning in or near 2022, in the absence of a Moffat Project and as more customers are added to the limited water supply, Denver Water would have to implement some combination of the following two strategies to manage supply and demand within the combined service area:

1. Deplete the Strategic Water Reserve, and/or
2. Rely on more frequent and severe Mandatory Water Use Restrictions.

It is impossible to accurately predict when or to what degree Denver Water would balance depletion of the Strategic Water Reserve and imposition of more frequent and severe mandatory restrictions. The balance would depend on numerous factors including storage conditions in Denver Water's North and South collection systems and hydrologic conditions. For example, Denver Water's strategy in response to a drought would depend on whether they are in the beginning or advanced stages of a drought. Each of these strategies is discussed individually below and then in combination.

Analysis of using the Strategic Water Reserve was accomplished quantitatively using the PACSM. In contrast, analysis of using mandatory restrictions was accomplished qualitatively.

2.10.2.1 Strategic Water Reserve Strategy

Description of Strategy

The Strategic Water Reserve of 30,000 AF/yr of firm yield is maintained within Denver Water's existing South System. Based on a storage-to-firm yield ratio of approximately 4:1, the Strategic Water Reserve equates to approximately 120,000 AF of water stored in Denver Water's reservoirs. The amount of Strategic Water Reserve in each reservoir varies depending on hydrologic conditions and the severity of a drought. The Strategic Water Reserve is located entirely in Denver Water's South System reservoirs, due to the imbalance in storage and raw water supplies between their North and South systems.

The Strategic Water Reserve would be reduced to help meet the need for up to an additional 15,000 AF/yr of water supply for Denver Water customers. Because of the imbalance between the North and South raw water collection systems and because there is no Strategic Water Reserve in the North System, there would still be shortages in the North System. This would result in periodic raw and treated water shortages to Denver Water customers.

PACSM Simulation of Depletion of the Strategic Water Reserve

PACSM was used to simulate and quantitatively compare hydrologic changes to stream flow and reservoir operations of the Strategic Water Reserve Strategy.

The No Action Alternative would require using part of the Strategic Water Reserve during drought periods. Over the 45-year study period, the Strategic Water Reserve would be drawn down in 4 years due to lack of water supply to meet customer demand (1955, 1956, 1957, and 1965). During the 1950s drought, approximately half of the 30,000 AF reserve would be used. This result assumes that (1) the raw and treated water systems have operated error-free during the entire study period, which is unlikely; (2) the Strategic Water Reserve has not already been needed to meet man-made and natural uncertainties and emergencies; and (3) future droughts would not be more severe than those experienced during the 1947 to 1991 study period.

The Strategic Water Reserve is only available in the South System, with none available in the North System. Due to the lack of storage in the North System, none of the Strategic Water Reserve would be available for use in Gross or Ralston reservoirs under the No Action Alternative, in which case the Moffat Collection System would run out of water in droughts. For example, model results show that the Strategic Water Reserve would not have been exhausted in 1955; however, these reserves would all be in storage in the south end of the system. Gross Reservoir and Ralston Reservoir would be down to their minimum operating storage creating a condition where a shortage to customers may occur. Raw water shortage would occur because Gross and Ralston reservoirs would be out of water. Additionally, treated water shortages may occur because Foothills and Marston WTPs would be operating at capacity, but the Moffat WTP, which is needed to help meet demand, would not have any water to treat. If one of the two remaining WTPs has an operation problem, Denver Water would not be able to meet customer water needs throughout its Combined Service Area from one WTP. During the summer, all three WTPs are required to meet customer demand.

Because the Moffat Collection System runs out of water in droughts, there would be shortages of water needed to supply the Moffat WTP and the Moffat Collection System raw water customers. The No Action Alternative results in shortages in meeting customer demands for treated and raw water deliveries due to lack of supply in 3 years of the 45-year study period (1955, 1957, and 1978). Based on the 1947 to 1991 study period, total raw water shortages of about 11,000 AF would have occurred in 1955, 1957, and 1978. Raw water shortages during the critical period would have been approximately 9,600 AF. Treated water shortages of approximately 550 AF would have occurred in 1955 due to lack of supply. The total treated water and raw water shortages would be approximately 10,000 AF during the mid-1950s drought period. While the Strategic Reserve is used to meet demands during the critical period, storage reserves in the North System are not sufficient, and would not result in shortages. When shortages occur during the critical period there is no Strategic Reserve in the North System. The 10,000 AF of shortage during the critical period equates to approximately 2,600 AF of firm yield. The need for new firm yield is 18,000 AF/yr even though the shortages under the No Action Alternative are less, in order to meet future demands and maintain and better balance the Strategic Reserve between Denver Water's North and South systems. The Strategic Reserve is not sufficient to meet an additional demand of 15,000 AF/yr due to the imbalance in storage and supplies in Denver Water's system (does not include 3,000 AF of additional demand from Arvada).

2.10.2.2 Mandatory Restrictions Strategy

Description of Strategy

The second of the two potential strategies for Denver Water would be to impose more frequent and severe mandatory water use restrictions on its customers sufficient to reduce water demands to equal available supplies during the critical drought periods while maintaining the Strategic Water Reserve. Presumably, this strategy would be formulated under Denver Water's operating rules as promulgated January 1, 2008.

Denver Water has adopted a Drought Response Plan that provides a framework for addressing droughts. Three levels of drought severity have been defined, based on the predicted percentage of storage in Denver Water's reservoirs at the end of the run-off season on July 1. The basic response to a Stage 1 drought is voluntary measures; to a Stage 2 drought, mandatory restrictions; and to a Stage 3 drought, prohibitions on lawn watering. To adopt a particular drought response, the Board of Water Commissioners declares a drought level and adopts an effective date for applicable restrictions. Because Stage 2 and Stage 3 drought restrictions are mandatory, they are incorporated into the Operating Rules where they become enforceable upon a drought declaration pursuant to the Denver Charter, the Denver Revised Municipal Code and provisions in Denver Water's water service agreements and water leases.

In addition to the three stages described above, Denver Water also has a Stage 4 response. Each of these drought stages is triggered by the expected or actual reservoir storage levels on July 1 in any given year (Denver Water 2004c). July 1 is used as the trigger date because storage in Denver Water's reservoirs usually reaches annual maximum around this time. The four stages of drought, the reservoir storage-level trigger, and the response appear below:

- Stage 1 – less than 80% full/voluntary restrictions
- Stage 2 – less than 65% full/mandatory restrictions
- Stage 3 – less than 40% full/no lawn watering
- Stage 4 – less than 25% full/severe restrictions throughout the system

As described in Denver Water's Drought Response Plan (Denver Water 2004d), Denver Water uses two methods based on reservoir levels as described above to reduce customers (which includes treated and raw water contracts) demand during times of system shortages depending on the type of contract: mandatory restrictions and curtailment of deliveries.

Mandatory Restrictions
Denver Water can impose a variety of programs designed at reducing customer demand. These programs may include: limiting days of irrigation, prohibiting the installation of new landscaping, prohibiting the use of water for cleaning an impervious surface, and others. Customers who have contracts subject to mandatory restrictions must adopt the same water use reductions adopted by Denver Water or impose their own mandatory restrictions that will reduce water use by the same amount (or more) than Denver Water's restrictions.

Curtailment of Deliveries

Once Denver Water imposes restrictions; it can curtail the delivery of water to some fixed water contracts. These curtailments are designed to reduce the customers' water use by the same percentage the mandatory restriction program is designed to save.

Based on Denver Water's 2002 through 2005 drought operations, mandatory restrictions may represent a strategy that Denver Water might adopt to meet its water supply needs if it does not obtain a Section 404 Permit for the Project. Since droughts are natural events that occur with unpredictable frequency and variable intensity and duration it is unknown how long the drought would last or how severe it would be. Given these facts, it is reasonable to assume that Denver Water would impose mandatory restrictions to preserve its ability to provide essential water supplies in the face of these uncertainties. Table 2-22 shows drought stage restrictions used by Denver Water in the 2002 through 2005 drought, which incorporated measures from the Drought Response Plan (Denver Water 2004d) and represent a strategy that Denver Water may also adopt in future droughts. As previously described, with the increased demand and demand hardening expected under the No Action Alternative, more severe restrictions would be expected than those adopted in the recent drought. Table 2-22 summarizes Denver Water's drought stage declarations from 2002 through 2005.

Table 2-22
Summary of Monthly Drought Restrictions
(2002 through 2005)

Month	2002	2003	2004	2005
January	—	Stage 2[1]	Stage 1	Stage 1
February	—	Stage 2[1]	Stage 1	Stage 1
March	—	Stage 2[1]	Stage 1	Stage 1
April	—	Stage 2[1]	Stage 1	Stage 1
May	Stage 1	Stage 2	Stage 2	—
June	Stage 1	Stage 2	Stage 2	—
July	Stage 2	Stage 2	Stage 2	—
August	Stage 2	Stage 2	Stage 2	—
September	Stage 2	Stage 1	Stage 1	—
October	Stage 2[1]	Stage 1	Stage 1	—
November	Stage 2[1]	Stage 1	Stage 1	—
December	Stage 2[1]	Stage 1	Stage 1	—

Source: Denver Water, 2004d.
Notes:
[1] Outdoor watering prohibited.
— = no monthly drought restrictions

Denver Water uses the following set of principles to guide the development of drought restrictions (Denver Water 2004d):

- Avoid irretrievable loss of natural resources
- Restrict less essential uses before essential uses
- Affect individuals or small groups before affecting large groups

- Minimize adverse financial effects on the community
- Eliminate water waste

The possible drought restrictions that could be imposed by Denver Water vary by the drought stage. Denver Water selects from among these measures, depending in part on conditions at the time. Since present and additional future conservation is also assumed under the No Action Alternative, further demand reductions would be more challenging, and the more stringent measures at each stage are likely to be adopted.

Stage 1 – The goal of these drought response measures is to reduce water use by 10% beyond savings anticipated from present and future water conservation programs. The recommended responses are voluntary requests to customers; public awareness, enacting Stage 1 restriction clause in contracts; preparing for a Stage 2 drought; and other measures.

Stage 2 – The goal of these drought response measures is to reduce water use by 30% beyond the savings anticipated from present and future water conservation programs. In addition to Stage 1 responses, the recommended responses are mandatory and allow outdoor watering only 2 days per week, implementing industry-specific restrictions, restricting or eliminating non-essential uses, designing a surcharge, and other measures.

Stage 3 – The goal of these drought response measures is to reduce water use by 50%. Recommended responses include prohibiting lawn watering, watering only trees and shrubs and high public use turf areas once a week, and other measures.

Stage 4 – Denver Water does not have a formal protocol for Stage 4 drought response. Denver Water's Drought Response Plan (2004d) states, "No outdoor watering will be allowed, and indoor water use will be restricted." At this stage of drought, no specific types of customers are targeted for restrictions; instead restrictions would occur throughout the system. Response to this stage of drought is largely undefined because of its extraordinary nature; therefore, Denver Water retains a great deal of flexibility in reacting to the unique situation of Stage 4 drought conditions.

The savings shown in Table 2-23 are the result of implementing restrictions during the 2002 through 2005 drought. These savings may not be indicative of future savings because drought conditions (i.e., frequency and duration) are highly variable. Additionally, Denver Water has adopted a water conservation plan and has instituted numerous water saving measures that are designed to make these savings permanent (Denver Water 2006a, 2011). The "Use Only What You Need" advertising campaign and Denver Water's goal to reduce per capita use are examples of the Denver Water's desire to achieve permanent savings (refer to Section 1.4.1.2 for additional conservation measures). If Denver Water is successful with its conservation plan, demand reductions under the same set of restrictions in the next drought would likely be less than the savings realized in the 2002 through 2005 drought.

Table 2-23
Summary of Monthly Water Demand Reductions
(2002 through 2005)

Month	2002	2003	2004	2005
January	—	-8%	-13%	-19%
February	—	-9%	-12%	-20%
March	—	-17%	-14%	-17%
April	—	-31%	-21%	-27%
May	13%	-37%	-26%	—
June	-3%	-42%	-39%	—
July	-19%	-27%	-42%	—
August	-13%	-16%	-33%	—
September	-30%	-21%	-25%	—
October	-36%	4%	-27%	—
November	-19%	-16%	-19%	—
December	-8%	-8%	-16%	—

Source: Denver Water, 2006a.
Note:
— = no monthly water demand reduction

Implementation of Strategy

Under the mandatory restrictions strategy, restrictions imposed on Denver Water customers would be more severe than those imposed by Denver Water in response to the 2002 drought. In 2002, the water demand was approximately 285,000 AF/yr, whereas under the No Action Alternative (2032), Denver Water's demand is estimated to be 360,000 AF/yr (379,000 AF/yr less 16,000 AF/yr of forecasted savings anticipated for implementing additional conservation measures less 3,000 AF/yr associated with the City of Arvada). As compared to 2002, there would be an additional 75,000 AF/yr of customer demand under the No Action Alternative, but no additional supplies (78,000 AF if Arvada's additional demand is included). In addition, the 16,000 AF of expected conservation would result in demand hardening. Denver Water's measures would include mandatory restrictions or water rationing, surcharges for water use, and the other measures outlined above for Stage 2 and Stage 3 droughts. Given the increased demands and normal conservation expectations, Stage 2 measures are likely to be more severe and prolonged compared with the 2002 through 2005 experience. At the most critical times, a Stage 3 drought response might be enacted. Furthermore, Denver Water can be expected to reduce or eliminate some or all minimum bypass flows on eastern and western slope streams. Denver Water can reduce bypass flows in the Fraser River Basin, below Dillon, Eleven Mile Canyon, and Cheesman reservoirs, and in Waterton Canyon under certain emergency or drought-related conditions. In general, the degree to which minimum bypass flows are reduced is contingent on the level of restrictions imposed and the amount of storage in Denver Water's reservoirs. Reductions in minimum bypass flows on the East Slope have not been exercised to date, whereas bypass flows in the Fraser River Basin have been reduced.

Under the mandatory restrictions strategy, Denver Water would need to impose drought restrictions more frequently than they have in the past. However, the actual Denver Water actions cannot be predicted, as Denver Water needs maximum flexibility to address each unique circumstance of shortage as it arises.

2.10.3 Definition of No Action Alternative

Description of Alternative

The most likely No Action Alternative is a combination of both depletion of the Strategic Water Reserve and implementation of more frequent and severe mandatory water use restrictions. Each of these components is described in the following discussion.

Implementation of Alternative

Depletion of the Strategic Water Reserve and implementation of more frequent and severe mandatory restrictions would generally occur in the same manner as described above under the individual strategies. The No Action Alternative implementation would be less intense than if either strategy were implemented independently, but the degree of intensity or the exact prescription is unknown because Denver Water has never faced this eventuality. This EIS qualitatively examines the diminished effects of both strategies in combination.

The environmental effects of the No Action Alternative, consistent with PACSM for the action alternatives, are analyzed at the total system's average demand of 363,000 AF/yr. This is the level of demand expected when Denver Water reaches Full Use of the Existing System (345,000 AF/yr of demand), plus the increased annual demand beyond through 2032 (18,000 AF/yr). Of the 18,000 AF/yr, 3,000 AF/yr would be from raw water demand stemming from a contractual commitment with by the City of Arvada. Table 2-24 is a summary of Denver Water's supply and demand at Full Use of the Existing System (without a Project alternative), with an action alternative implemented (2032), and under the No Action Alternative (2032).

Table 2-24
Summary of Denver Water's Supply and Demand

Condition	Supply (AF/yr)	Demand (AF/yr)
Full Use of the Existing System (without a Moffat Project alternative)	345,000	345,000
Action Alternatives (2032, Existing System plus new Moffat Project supply and an additional 18,000 AF of demand)[1]	363,000	363,000[1]
No Action Alternative (2032, Existing System without new Moffat System Project and an additional 18,000 AF of demand)[1]	345,000	363,000[1]

Notes:
[1] The demand includes 3,000 AF of firm yield of additional demand for the City of Arvada.
AF = acre-feet
AF/yr = acre-feet per year

2.10.4 Implications of the No Action Alternative

The implementation of the No Action Alternative would have certain unavoidable implications or effects that would lead to impacts upon hydrologic, environmental, and socioeconomic resources, as identified below and described for each resource in Chapter 5.

2.10.4.1 Susceptibility to Unforeseen Challenges to the Water Supply System

The No Action Alternative would result in depletions of storage compared to the action alternatives, which would lead to hydrologic effects that differ from the action alternatives (refer to Section 5.1). The depletion of the Strategic Water Reserve would also subject Denver Water and its customers to higher risks because it would not be available for emergencies in drought years. The system would be more vulnerable to unforeseen circumstances, reducing its reliability. Flexibility to respond to various operational requirements would be reduced. This all assumes that the remaining system operates completely error-free throughout this crisis; an unlikely condition.

2.10.4.2 Raw Water Shortages

Raw water shortages would occur during drought periods because Gross Reservoir and Ralston Reservoir would be drawn down to their minimum storage capacities. During this time, Denver Water would be unable to meet its contractual commitments to the raw water customers served by the North System, including North Table Mountain, Arvada, Westminster, Consolidated Mutual Water Company, Arvada Long Lakes Ranch (Parks Department), and Department of Energy (Rocky Flats/Department of Energy). There would be no shortages to raw water delivery contracts on the South System. However, during the recent drought, Denver Water chose to uniformly apply restrictions to all the customers regardless of water source. For example, at times, excess reusable effluent was available, but Denver Water required raw water customers (who use reusable water as a source) to curtail their water use in order to treat all customers equally.

Raw water contract terms and conditions vary between entities. In the event that deliveries cannot be made, a legal review of obligations would be needed and Denver Water would need to determine how to respond based on the conditions. Based on past Denver Water responses and some limited modeling results, the following scenarios describe one possible outcome of limited supplies in the North System.

The majority of raw water delivery contracts and leases provide for reduced deliveries during times of shortages, but are limited to either putting customers on the same restrictions or a reduction in deliveries similar to the savings that are expected in Denver Water’s Combined Service Area (refer to Figure 1-4). Restrictions would likely be applied both in the Combined Service Area and raw water deliveries should North System shortages occur. Regardless, Arvada, Westminster, and North Table Mountain would be especially vulnerable to drought under the No Action Alternative as they cannot take delivery of water from Denver Water’s other raw water sources.

Arvada would experience both a reduction in raw water deliveries it currently receives and the loss of 3,000 AF/yr of Denver Water’s future obligatory water that is contingent upon Denver Water developing additional firm yield from the Moffat Collection System. Denver

Water would not be obligated to deliver this 3,000 AF/yr, therefore, this would represent a loss of future supply to Arvada.

2.10.4.3 Unmet Treated Water Demands

Based upon a PACSM simulation in which the Strategic Water Reserve is depleted, treated water customers would face a shortage of approximately 550 AF due to a lack of supply during the critical period. This prospect, along with the prospect of raw water customer shortages and a depletion in the Strategic Water Reserve, would likely encourage Denver Water to impose a drought response, including more frequent and severe mandatory water restrictions and other Stage 2 or Stage 3 drought response measures. These would occur with greater frequency for longer periods and with more severity than they would under the action alternatives. These water restrictions would likely be applied to all Denver customers, regardless of type and location, and certain normally-satisfied demands would go unmet. Under the No Action Alternative, the unmet demands would be more pronounced and more frequent than would be experienced under the action alternatives.

2.10.4.4 Increased Treatment Plant Vulnerability

Under the No Action Alternative, the Moffat WTP would be intermittently shut down during mid-October through March or April every year to preserve the limited Moffat Collection System water supplies. Shutting down the Moffat WTP from mid-October through April is consistent with historical and current operations. These shutdowns would be needed in anticipation of future drought conditions, to avoid completely depleting the North System of water—a logistically catastrophic scenario. With the Moffat WTP shut down, whether intermittently or continuously for an average of 6 months per year, only two of Denver Water's three WTPs are available for meeting customer water demands or for reacting to planned and unplanned outages at either of the two operating WTPs. During this time, Denver Water's 1.3 million customers will be dependent upon only one WTP at any time. Foothills or Marston WTP will have to be shut down for routine maintenance during the winter.

Generally, each WTP needs to be taken out of service at least once each winter season for maintenance. There are portions of each plant that cannot be inspected or repaired during operation because they are submerged. There have been circumstances, such as major capital improvements at a facility, which require it to be out of service for an extended period of time. During these times, the other two WTPs are intentionally not taken out of service, and the planned annual outage may not occur, may be postponed, or the outage period and repairs may be significantly lessened.

Denver Water's objective is that at least two WTPs should be running at any given time, because one may have to be shut off due to operational issues, water quality problems, or any other unexpected challenges. If one plant needs to be shut down, the other operating plant can increase production fairly quickly, but re-starting a WTP after it has been completely shut down takes considerably longer and has an increased likelihood of encountering problems. When either Marston or Foothills WTP is down, it is a priority for Denver Water to have the Moffat WTP running.

Having only one WTP operational represents a single point of failure because the treated water system has only one to two days of available supply. Any unforeseen circumstance, such as an electrical fire, major equipment failure, contamination of the source water, or natural disaster, could leave Denver Water's Combined Service Area without any water or fire protection. To bring a WTP that is off-line to operational status can take several days. There is not enough storage in the distribution system to supply the Denver Water's Combined Service Area during an extended period with no treatment plant running (or while waiting for a plant to come on-line). Some portions of the Combined Service Area would likely run dry within a half-day. Running the system dry (or even portions of it) has health consequences and would also result in a complete, but temporary, loss of fire protection. As such, system redundancy is critical.

2.10.4.5 Drawdown of Gross Reservoir

As a result of the level of imbalance in the raw water collection system under the No Action Alternative, Denver Water would also frequently draw Gross Reservoir down to the minimum operating level in order to meet the increased demand. Based upon a PACSM simulation in which the Strategic Water Reserve is used to help meet Denver Water's additional demand, Gross Reservoir would be at the minimum operating level approximately once every 5 years compared to approximately once every 25 to 30 years under the action alternatives.

Additionally, under the No Action Alternative, Gross Reservoir would continue to stay at the minimum operating level for at least 6 months in many of the years, and therefore be unable to supply water.

2.11 COMPARISON OF ALTERNATIVES

2.11.1 Comparison of Alternative Elements

The Proposed Action and four action alternatives vary in engineering complexities and cost. Table 2-25 provides a summary of the major characteristics and impacts for each alternative.

Ground Disturbance

The estimated temporary and permanent ground disturbance associated with each action alternative is also summarized in Table 2-25. There would be no ground-disturbing activities associated with the No Action Alternative. Temporary disturbance is the land area disturbed by construction activities (e.g., staging, spoil and stockpile area, pipelines, etc.). A portion of these areas would be restored to their approximate original condition after construction. Permanent disturbance is the land area to be physically altered for the life of the Project (e.g., dam footprint, reservoir inundation area, advanced water treatment, pump stations, etc.). Refer to Appendix D-2 for the estimated disturbance areas by component.

Proposed Action with the Environmental Pool for Mitigation

The estimated ground disturbance for the Proposed Action conservatively assumed the proposed inundation area (i.e., the area between elevation 7,282 and 7,400 feet), plus 10 feet above the expanded reservoir pool to account for potential tree removal and other construction-related activities. The additional area of inundation associated with the Environmental Pool (i.e., the area between elevation 7,400 and 7,406 feet) is within this impact area. Thus, the impact analysis of ground-disturbance associated with the Proposed Acton with or without the Environmental Pool is the same. For other potential impacts associated with the Environmental Pool such as hydrology, recreation and aquatic biological resources, refer to the additional analysis presented in Appendices H-22 and M-2.

2.11.2 Comparison of Impacts

Detailed discussion of the environmental consequences is presented in Chapter 5. A comparative summary of the potential impacts by resource discipline for each action alternative and the No Action Alternative is presented in Chapter 5, Table 5.22-1 (by alternative) and Table 5.22-2 (river segments). The tables allow the reader and decision-maker to compare potential effects by discipline and alternative.

Table 2-25
Summary of Major Characteristics and Impacts of Alternatives

Characteristic	Proposed Action (Alternative 1a)	Alternative 1c	Alternative 8a	Alternative 10a	Alternative 13a	No Action Alternative
Water Source(s)	Moffat Collection System[1]	Moffat Collection System	Moffat Collection System Unused reusable water in the South Platte River	Moffat Collection System Unused reusable return flows from the Denver Water Recycling Plant	Moffat Collection System New agricultural water rights converted to municipal/ industrial use	Moffat Collection System Strategic Water Reserve Blue River and South Platte River[2]
Gross Reservoir Expansion (Additional Storage Capacity with the Environmental Pool for Mitigation)	77,000 AF	40,700 AF	52,000 AF	52,000 AF	60,000 AF	—
Other Storage Component	—	New Leyden Gulch Reservoir (31,300 AF)	Gravel Pit Storage (5,000 AF)	Denver Basin Aquifer Injection/ Extraction Wells (20,000 AF)	Gravel Pit Storage (3,625 AF)	—
Treatment Facilities	—	—	Advanced Water Treatment (13.6 mgd) Dechlorination Facility	Advanced Water Treatment (13.6 mgd)	Advanced Water Treatment (10.8 mgd) Dechlorination Facility	—
Pipelines	—	Minor relocation of South Boulder Diversion Canal	Conduit O Gravel Pit Pipelines	Conduit M Aquifer Distribution Pipelines	Conduit O Gravel Pit Pipelines	—
Disturbance Areas[3]						
• Permanent (acres)	465.6[4]	690.7	370.7	382.4	420.0	—
• Temporary (acres)	89.3	281.1	117.8	123.2	114.4	—
• Temporary Conduit Disturbance (miles)	—	—	27.3	54.5	30.7	—

Table 2-25 (continued)
Summary of Major Characteristics and Impacts of Alternatives

Characteristic	Proposed Action (Alternative 1a)	Alternative 1c	Alternative 8a	Alternative 10a	Alternative 13a	No Action Alternative
Costs						
Total Construction Cost	$139.9 million	$293.7 million	$362.0 million	$393.2 million	$426.7 million	—
Annual O&M Costs	$291,000	$612,000	$4.9 million	$6.0 million	$3.9 million	—
Present Worth of Annual O&M (80 years)	$8.8 million	$18.5 million	$147.7 million	$181.5 million	$118.4 million	—
Total Present Worth Cost	**$148.7 million**	**$312.2 million**	**$509.7 million**	**$574.7 million**	**$545.1 million**	—

Source: Denver Water, 2006d; Harvey Economics, 2007, 2008.

Notes:

[1] Moffat Collection System – average and wet-year water in the Fraser and Williams Fork river basins and South Boulder Creek.

[2] All action alternatives collect water from the Blue River, South Platte River, and South Boulder Creek.

[3] Permanent disturbance is the total land area that remains after reclamation to be physically altered for the life of the Project. Temporary disturbance is the total land area disturbed by construction activities, a portion of which will be reclaimed upon completion of construction activities. Temporary conduit disturbance assumes that the proposed pipelines would be installed within existing roads, curb-to-curb. Only a temporary linear disturbance was calculated.

[4] The acres assume disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir and the Environmental Pool (elevation 7,406 feet).

— = not applicable
AF = acre-feet
mgd = million gallons per day
O&M = operation and maintenance

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